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TECHNICAL REPORT No. 70-2

OPERATION OF THE UINTA BASIN SEISMOLOGICAL OBSERVATORY

Final Report, Project VT/9703
Contract F33657-69-C-0759
1 January through 31 December 1969

Sponsored by

Advanced Research Projects Agency
Nuclear Test Detection Office
ARPA Order No. 624

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TELEDYNE GEOTECH
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Garland, Texas

15 April 1970

IDENTIFICATION

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ABSTRACT

This report describes the operations of the Uinta Basin Seismological Observatory (UBSO) from 1 January through 31 December 1969. Also discussed are the maintenance and testing of the UBSO digital data acquisition system.

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1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center (AFTAC), under Contract F33657-69-C-0759. The statement of work for this contract is shown in appendix 1.

1.2 HISTORY

The Uinta Basin Seismological Observatory (UBSO) was constructed under Contract AF 33(657)-7185. Site selection and noise surveys were accomplished by Geotech; the final decision on the observatory location was made by AFTAC. Texas Instruments Incorporated (TI), was responsible for the construction of all physical facilities.

Contract AF 33(600)-43486, issued to TI, contained the authority for equipping and operating UBSO. The instrumentation was supplied by Geotech and was installed under the direction of Geotech personnel under subcontract to TI. Texas Instruments operated the observatory from November 1962 until 1 July 1963. Geotech operated UBSO from 1 July 1963 through 31 December 1968 under Projects VT/1124 and VT/5054 of Contract AF 33(657)-12373 and Project VT/6705 of Contract AF 33(657)-16563.

2. SUMMARY

During this report period, the majority of the work done at UBSO was directed toward the routine operation and maintenance of the short-period, three-component seismograph system; the short-period, 10-element, shallow-buried array; the short-period earth-powered vertical seismograph; and the long-period, 3-component, 7-element array. Data from these seismographs, together with time and environmental data, were recorded 24 hours per day, 7 days per week on 16-mm film and on magnetic tape.

Data recorded on 16-mm film were routinely analyzed to determine the time, period, peak amplitude, and preliminary identification of each phase arrival. This information was sent daily to the ESSA-C&GS, Washington, D. C., by teletype.

Operation of the short-period vertical array was discontinued in April and all seismometers were removed from the deep well.

Quality of all data recorded at UBSO was monitored and controlled by an independent Quality Control Group at Garland, Texas.

For the first time since we assumed observatory operation on 1 May 1966, lightning activity was severe enough to damage observatory equipment. Solid-state components in remote-site equipment suffered the greatest damage, but lightning at the central recording building was severe enough to damage commercial power circuits.

The reliability of the long-period array system was evaluated and causes of failure were studied. Transistors were found to have caused the largest proportion (46.4%) of all failures.

3. OPERATION OF UBSO

3.1 GENERAL

Data were recorded at UBSO on a 24-hour basis. The observatory was normally manned 8 to 10 hours a day, 5 days a week. On weekends and holidays, a skeleton crew manned the observatory 8 hours a day; however, additional personnel were on call in case of emergency. Figure 1 is the organization chart for Project VT/9703.

3.2 ORIENTATION OF THE UBSO SEISMOGRAPH ARRAYS

Figures 2 and 3 show the orientation of the UBSO short-period arrays and long-period array, respectively.

3.3 SEISMOGRAPH OPERATING PARAMETERS

3.3.1 Standard Seismographs

The operating parameters and the tolerances for the standard observatory seismographs are shown in table 1. These parameters are reset if the frequency response of a seismograph is found to be out of tolerance. The frequency response norms and their respective tolerances are shown in table 2. The frequency responses of the UBSO seismographs, as normally operated, are shown in figure 4.

3.3.2 Filters for Shallow-Buried Array Summations

The summation of the 10-element shallow-buried array is filtered by a band-pass filter with the following settings: a high-cut corner frequency of 3 cps and a low-cut corner frequency of 0.8 cps, both at a cutoff rate of 18 dB per octave.

3.4 SUMMARY OF UBSO DATA FORMATS AND SEISMOGRAPH OPERATING MAGNIFICATIONS

In compliance with AFTAC specifications, each data format recorded at the observatory is assigned a data group number. When a data format is changed, a data group number is assigned to the new format and reported to the Project Officer.

Standard operating magnifications were assigned to each seismograph system based on the level of the microseismic noise commonly observed on the particular system. After standards were established, the magnifications were maintained within specified tolerances.

Data formats used with Develocorder film seismograms during the reporting period are listed in table 3, and those used with magnetic tape seismograms are listed in table 4. A key to designations used in data format assignments is presented in table 5.

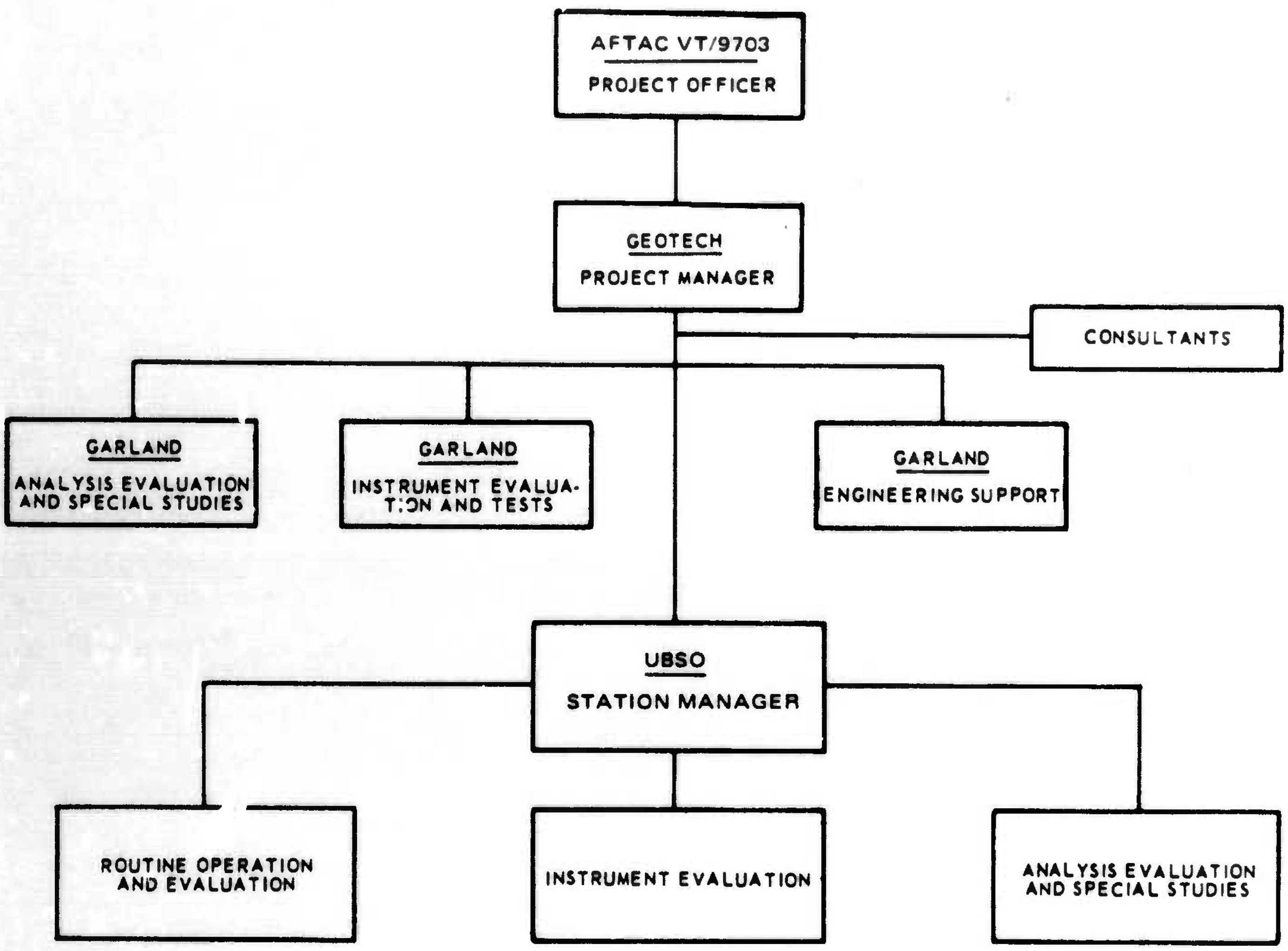

Figure 1. Organization for Project VT/9703

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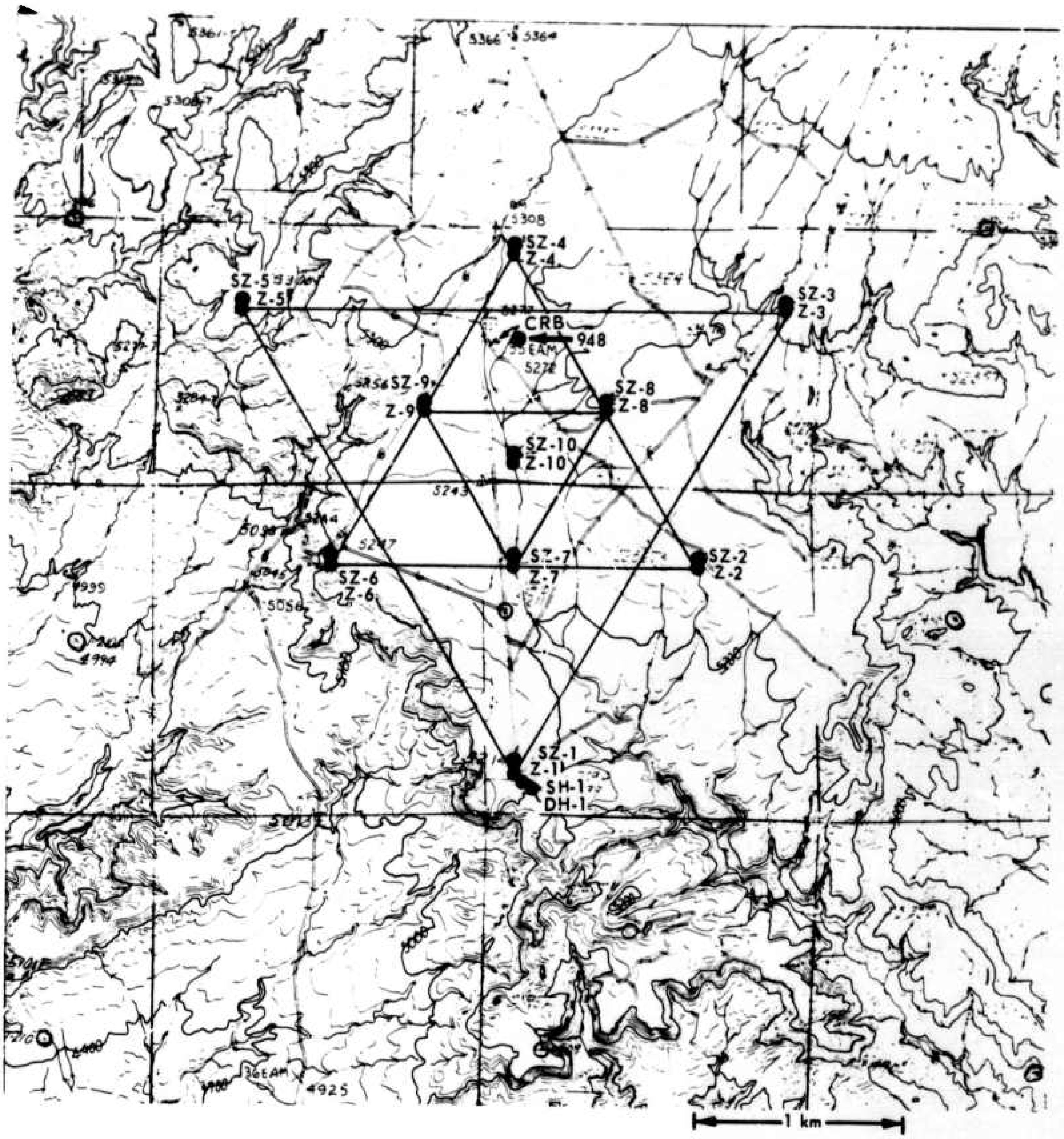

Figure 2. Orientation and configuration of UBSO short-period arrays

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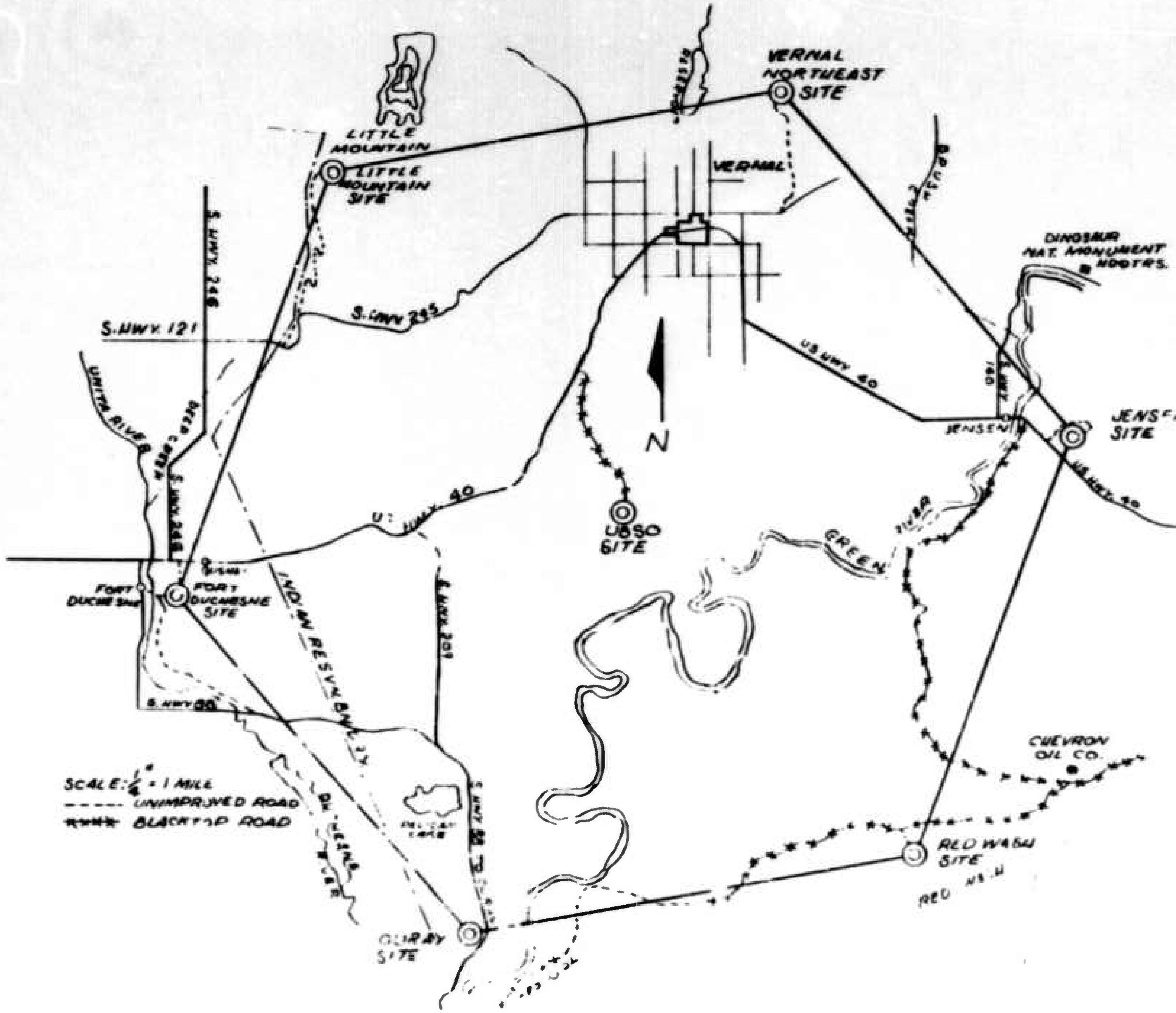

Figure 3. LP array shown in relation to main access routes and local landmarks

G 4989

Table 1. Operating parameters and tolerances of seismographs at UBSO

Seismograph		Seismometer		Operating parameters and tolerances					Filter settings	
System	Comp	Type	Model	T_s	λ_s	T_g	λ_g	σ^2	Bandpass at 3 dB cutoff (sec)	Cutoff rate at SP side (dB/oct)
SP	Z	Johnson-Matheson	6480	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.03	0.1-100	12
SP	H	Johnson-Matheson	7515	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.03	0.1-100	12
SP	SZ	Geotech	18300	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.053	0.1-100	12
SP	Z	UA Benioff	1051	1.0 ±5%	1.0	0.083±5%	1.4	1.0	---	--
LP	Z	Geotech	7505A	20.0 ±5%	0.77 ±5%	---	---	0.00	60-275	6
LP	H	Geotech	8700A	20.0 ±5%	0.77 ±5%	---	---	0.00	60-275	6
LP[a]	Z	Geotech	7505A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	0.63	25-1000	12

SP Short period
LP Long period (digital systems)
UA Unamplified (i.e., earth powered)

[a] Long-period vertical system using PTA

T_s Seismometer free period (sec)
T_g Galvanometer free period (sec)
λ_s Seismometer damping constant
λ_g Galvanometer damping constant
σ^2 Coupling coefficient

Table 2. Calibration norms and operating tolerances for frequency responses of the standard seismographs at UBSO

SP vertical 18300 and SP Johnson-Matheson vertical and horizontal

F (cps)	T (sec)	R.M.	A.T. (± %)
0.2	5.0	0.0113	10
0.4	2.5	0.0950	7.5
0.8	1.25	0.685	5
1.0	1.0	1.0	-
1.5	0.67	1.52	5
2.0	0.5	1.90	5
3.0	0.33	2.12	7.5
4.0	0.25	1.87	12
6.0	0.167	1.15	20

LP vertical and horizontal (filtered output, 16-millimeter film and FM magnetic-tape seismograms)

F (cps)	T (sec)	R.M.	A.T. (%)
0.01	100	0.190	20
0.0125	80	0.328	20
0.0167	60	0.615	15
0.02	50	0.820	15
0.025	40	1.05	10
0.033	30	1.07	5
0.04	25	1.0	0
0.05	20	0.698	5
0.0667	15	0.320	10
0.10	10	0.061	20

LP vertical (PTA system)

F (cps)	T (sec)	R.M.	A.T. (%)
0.01	100	0.063	20
0.0125	80	0.130	20
0.0167	60	0.257	15
0.02	50	0.380	15
0.025	40	0.586	10
0.033	30	0.903	5
0.04	25	1.0	0
0.05	20	0.810	5
0.0667	15	0.345	10
0.10	10	0.058	20

LP vertical and horizontal (unfiltered data digital-tape seismograms)

F (cps)	T (sec)	R.M.	A.T. (%)
0.01	100	0.040	20
0.0125	80	0.082	20
0.0167	60	0.195	15
0.02	50	0.320	15
0.025	40	0.542	10
0.033	30	0.825	5
0.04	25	1.0	0
0.05	20	0.994	5
0.0667	15	0.800	10
0.10	10	0.452	20

Key

R.M. - relative magnification
A.T. - amplitude tolerance

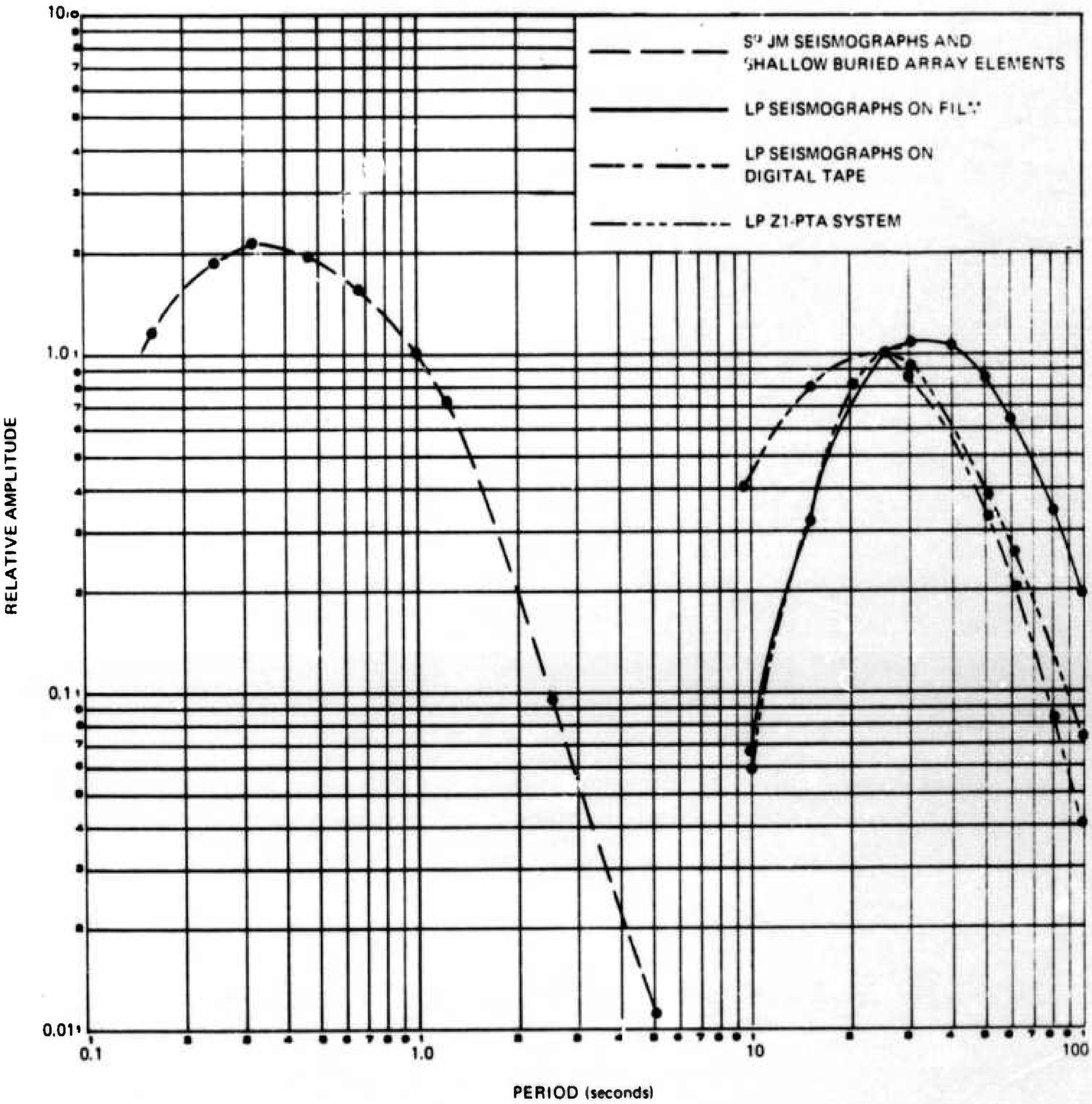

Figure 4. Normalized response characteristics of the routine seismographs at UBSO

Table 3. Develocorder data channel assignments

Channel No.	Data group 5044 20 Jul 66-31 Dec 69 SP primary Trace	Mag	Data group 5076 1 Jul 67-31 Dec 69 SP secondary Trace	Mag	Data group 5072 17 Dec 66-8 Apr 69 MAP 11 Trace	Mag	Data group 5084 25 Apr 68-8 Apr 69 Vertical array Trace	Mag
1	V	2-20K	SZ10L	60K	Test	--	V	2-20K
2	SZ1	600K	NSPL	60K	MCF11	Testing	MS1	.75 μb/mm
3	SZ3	600K	ESPL	60K	MCF12	Testing	MS2	.75 μb/mm
4	SZ5	600K	Z10LL	5K	MCF13	Testing	DH6	--
5	SZ2	600K	NSPLL	5K	MCF14	Testing	DH5	--
6	SZ4	600K	ESPLL	5K	MCF15	Testing	DH4	--
7	SZ6	600K	SZ1	600K	MCF16	Testing	DH3	--
8	SZ7	600K	SZ3	600K	MCF17	Testing	DH2	--
9	SZ8	600K	SZ5	600K	BSSV1	Testing	DH1	--
10	SZ9	600K	ΣSSF	6000K	BSSV2	Testing	ΣDHF	--
11	ΣSSF (Geotech)	6000K	ΣSS	1500K	BSSV3	Testing	ΣDH	--
12	ΣSS	1500K	Z10	600K	BSSV4	Testing	SZ1	
13	SZ10	600K	NSP	600K	BSSV5	Testing	W1	5 mph=1 mm S=0/8 mm (E=6)
14	NSP	600K	ESP	600K	BSSV6	Testing	WWV	--
15	ESP	600K	TCDMG (Tape 1)	---	ΣDVS	Testing		
16	WWV	--	WWV	---	WWVb	--		

Table 3 (Continued)

Channel No.	Data group 5090 16 Oct 68-31 Dec 69 LP primary Trace	Mag	Data group 5092 16 Oct 68-10 Apr 69 No 2 Trace	Mag	Data group 5096 11 Apr 69-31 Dec 69 No. 2 Trace	Mag	Data group 5094 16 Oct 68-31 Dec 69 No. 3 Trace	Mag
1	SZ10	250K	ZLPD1	50K	ZLPD1	50K	NLPD1	25K
2	WI	3 mph=1 mm / S=0/8 (E=6)	ZLPD2	50K	ZLPD2	50K	NLPD2	25K
3	ZLPD1	50K	ZLPD3	50K	ZLPD3	50K	NLPD3	25K
4	NLPD1	50K	ZLPD4	50K	ZLPD4	50K	NLPD4	25K
5	ELPD1	50K	ZLPD5	50K	ZLPD5	50K	NLPD5	25K
6	ZLP1	50K	ZLPD6	50K	ZLPD6	50K	NLPD6	25K
7	NLP1	50K	ZLPD7	50K	ZLPD7	50K	NLPD7	25K
8	ELP1	50K	ΣZLPD	50K	ΣZLPD	50K	ELPD1	25K
9	ML1	3.40 μb/mm	ΣNLPD	50K	ΣNLPD	50K	ELPD2	25K
10	ML2	3.40 μb/mm	ΣELPD	50K	ΣELPD	50K	ELPD3	25K
11	ZLP1L	10K	WWV	--	ZLP1X	50K	ELPD4	25K
12	NLP1L	10K			ZLPD1	50K	ELPD5	25K
13	ELP1L	10K			WWV	--	ELPD6	25K
14	WWV	--					ELPD7	25K
15							WWV	--
16								

Table 4. FM magnetic-tape recorder data channel assignments

Channel No.	Data group 5025 20 Jul 66-31 Dec 69 No. 3 Trace	Data group 5045 15 Feb 68-19 Mar 69 No. 4 Trace	Data group 5053 6 Oct 68-31 Dec 69 No. 1 Trace	Data group 5055 6 Oct 68-31 Dec 69 No. 2 Trace
1	TCDMG	TCDMG	TCDMG	TCDMG
2	SZ1	DH1	ZLP1	ZLPD1
3	SZ2	DH2	NLP1	ZLPD2
4	SZ3	DH3	ELP1	ZLPD3
5	SZ4	DH4	NSP	ZLPD4
6	SZ5	DH5	ESP	ZLPD5
7	Comp.	Comp.	Comp.	Comp.
8	SZ6	DH6	No Data	ZLPD6
9	SZ7	ΣDH	No Data	ZLPD7
10	SZ8	ΣDHF	No Data	LPD Test
11	SZ9	SZ1	Z10LL (5K)	LPD Test
12	SZ10	ΣSS	NSPLL (5K)	LPD Test
13	ΣSS	ΣSSF	ESPLL (5K)	LPD Test
14	WWV & Voice	WWV & Voice	WWV & Voice	WWV & Voice

Table 5. Key to the designations used in the data format assignments at UBSO

BSSV1	Beam steering summation designed to emphasize recording of up-going vertically incident P waves
BSSV2	Beam steering summation designed to emphasize recording of P waves with apparent horizontal velocity of 8.1 km/sec
BSSV3	Beam steering summation designed to emphasize recording of S waves with apparent horizontal velocity of 8.1 km/sec
BSSV4	Beam steering summation designed to emphasize recording of down-going vertically incident P waves
BSSV5	Beam steering summation designed to emphasize recording of down-going P waves with apparent horizontal velocity of 8.1 km/sec
BSSV6	Beam steering summation designed to emphasize recording of down-going S waves with apparent horizontal velocity of 8.1 km/sec
Comp	Compensation
DH	Vertical array short-period seismograph
DH1	Vertical array element @ 8895 feet
DH2	Vertical array element @ 7903 feet
DH3	Vertical array element @ 6910 feet
DH4	Vertical array element @ 5894 feet
DH5	Vertical array element @ 4901 feet
DH6	Vertical array element @ 3907 feet
ELP1	East-west long-period seismograph at site 1 with PTA
ELP1L	ELP1 low magnification channel
ELPD	East-west long-period digital seismograph at site identified by suffix number
ESP	Amplified east-west short-period seismograph
ESPL	ESP low magnification channel
ESPLL	ESP very low magnification channel
LPD	Long-period digital seismograph
Mag	Magnification (see note)

Table 5 (Continued)

MCF11	Multichannel filtering designed to emphasize recording of vertically incident P waves and reject dominant noise (subsurface array)
MCF12	Multichannel filtering designed to emphasize recording of vertically incident P waves and reject dominant noise, with summation of the subsurface array as rings (1-3-5, 2-4-6, 7-8-9, 10) and the six elements of vertical array
MCF13	Multichannel filtering designed to emphasize recording of vertically incident P waves and reject dominant noise (vertical array)
MCF14	Multichannel filtering designed to emphasize recording of vertically incident P waves (up-going) using the 1st, 3d, and 5th deepest elements (deghosting minimizes reflection)
MCF15	Multichannel filtering designed to emphasize recording of vertically incident P waves (down-going) using 1st, 3d, and 5th deepest elements (deghosting minimizes 1st arrival)
MCF16	Multichannel filtering designed to emphasize recording of vertically incident P waves (up-going) using 2d, 4th, and 6th deepest element (deghosting minimizes reflection)
MCF17	Multichannel filtering designed to emphasize recording of vertically incident P waves (down-going) using 2d, 4th, and 6th deepest elements (deghosting minimizes 1st arrival)
ML1	Long-period microbarograph - monitors pressure inside LP vault
ML2	Long-period microbarograph - monitors pressure outside LP vault
MS1	Short-period microbarograph - monitors pressure inside LP vault
MS2	Short-period microbarograph - monitors pressure outside LP vault
NLP1	North-south long-period seismograph at site 1 with PTA
NLP1L	NLP1 low magnification channel
NLPD	North-south long-period digital seismograph at site identified by suffix number
NSP	Amplified north-south short-period seismograph
NSPL	NSP low magnification channel
NSPLL	NSP very low magnification channel
ΣDH	Summation of DH1 through DH6
ΣDHF	ΣDH filtered

Table 5. (Continued)

ΣDVS	Summation of six vertical array elements (with MAP bandpass filter)
ΣSS	Summation of SΣ1 through SΣ10
ΣSSF	ΣSS filtered
SΣ	Amplified vertical short-period seismograph from a shallow-buried site identified by a suffix number
ΣZLPD	Summation of ZLPD1 through ZLPD7
ΣNLPD	Summation of NLPD1 through NLPD7
ΣELPD	Summation of ELPD1 through ELPD7
Test	Test instrumentation
TCMDG	Time code management data group
V	Unamplified vertical short-period seismograph
WI	Anemometer - wind speed & direction
WWV	Radio time - (WWV, STS, and voice on tape)
WWV[b]	WWV will lead MAP time by 1 second
Z	Amplified vertical short-period seismograph from a site identified by a suffix number
ZLP1	Vertical long-period seismograph at site 1 with PTA
ZLP1L	ZLP1 low magnification channel
ZLP1X	Vertical long-period seismograph at site 1, with data taken from output of solid-state preamplifier (at input to digital system). ZLPD1 is corresponding data at output of digital system)
Z10LL	Vertical short-period seismograph at site 10, operated at very low magnification
ZLPD	Vertical long-period digital seismograph at site identified by suffix number

NOTE

Magnification of:

Short-period measured at 1 cps
Broad-band measured at 0.8 cps
Long-period measured at 0.04 cps
MCF measured at 1 cps
BSS measured at 1 cps

3.5 EQUIPMENT MALFUNCTIONS

Component failure information is coded in a format suitable for punching on standard 80-column IBM cards. A computer program is available which can handle 10 different types of subassemblies and 25 different components for each subassembly. The program can be utilized to give an overall picture of the equipment malfunctions experienced during any period.

3.6 CALIBRATION OF THE TEST EQUIPMENT

A major portion of the test equipment is checked and calibrated by personnel at the observatory.

Routine calibration of the test equipment was accomplished by use of a 1-percent standard meter. This meter is sent to the Garland laboratory for a calibration check every 3 months. A dual equipment calibration record/log for each item of test equipment has been kept up to date by the observatory and the Garland laboratory during this reporting period.

3.7 ROUTINE SHIPMENT OF DATA TO THE SEISMIC DATA LABORATORY (SDL)

Magnetic-tape seismograms were shipped to SDL about 15 days after the end of the month during which they were recorded. The primary and secondary short-period and the long-period 16-millimeter film seismograms and their corresponding operating logs were shipped to SDL about 45 days after the end of the month during which they were recorded.

3.8 QUALITY CONTROL OF THE RECORDED DATA

3.8.1 <u>FM Magnetic-Tape Seismograms</u>

Routine quality control checks of randomly selected FM magnetic-tape seismograms were made in Garland to assure that recordings meet specified standards. The following are among the items that were checked by the Quality Control Group.

a. Tape and box labeling;

b. Accuracy, completeness, and neatness of logs;

c. Adequate documentation of logs by voice comments on tape where applicable;

d. Seismograph polarity;

e. Level of calibration signals;

f. Relative phase shift between array seismographs;

g. Level of the microseismic background noise;

h. Level of the system noise;

i. PTA dc balance;

j. Oscillator alignment;

k. Quality of the recorded WWV signal where applicable;

l. Time pulse carrier;

m. Binary coded digital time marks.

3.8.2 Digital Magnetic-Tape Seismograms

Digital magnetic-tape seismograms were checked each week or oftener to determine record quality. Items checked included the following:

a. Tape and box labeling;

b. Accuracy, completeness, and neatness of logs;

c. Seismograph polarity;

d. Level of calibration signals;

e. Level of microseismic background noise.

In addition, quality control work was extended to include aid in diagnosing malfunctions in the digital seismograph. Three computer programs were used to detect tape parity errors, transmission parity errors, word length errors, tape skew, gain-ranging errors and system nonlinearities. This was accomplished in Garland because UBSO lacked the tape playback equipment, computer, and printer needed to perform readout and diagnosis of the digital tapes recorded there.

3.8.3 Sixteen-Millimeter Film Seismograms

Quality control checks of randomly selected runs of 16-millimeter film from the shallow-buried array, the surface array, and the long-period seismographs and the associated operating logs were made in Garland. Items that were routinely checked by the quality control analyst include:

a. Film boxes - neatness and completeness of box markings;

b. Develocorder logs - completeness, accuracy, and legibility of logs;

c. Film:

(1) Quality of the overall appearance of the record (for example, trace spacing and trace intensity);

(2) Quality of film processing;

d. Analysis - completeness, legibility, and accuracy of the analysis sheets.

Results of these evaluations were sent to the observatory for review and comment by the observatory personnel.

3.9 SECURITY INSPECTIONS

On 26 February, Mr. Glenn W. Luster of the Salt Lake City, Utah, office of Defense Contract Administration Services conducted a security inspection by telephone. Mr. Luster visited the observatory on 13 June, to conduct his annual on-site security inspection.

3.10 FACILITIES AND EQUIPMENT MAINTENANCE

3.10.1 Facilities Maintenance

3.10.1.1 Air Conditioning System

The air conditioning system became inoperative on 2 July. This failure was caused by broken valve reeds in both heads of compressor No. 1. We ordered the necessary parts and returned the system to operation on 9 July. At this time, we discovered that the drive shaft and the flywheel on the compressor were damaged when the key was sheared. The flywheel could not be kept securely attached to the shaft and the unit began experiencing severe vibration. On 14 August the flywheel on compressor No. 2 was transferred to compressor No. 1. The defective flywheel was repaired by a local machine shop and the complete system was returned to operation on 16 August. The single compressor could not handle the entire building load and the temperature rose to 85°F. As a result of the elevated temperature, we lost a fuse in the Wanlass voltage regulator and several data sets became erratic. The system became inoperative again on 28 July due to a leak in the refrigerant line of compressor No. 2. A local repairman was called to resolder the joint and charge the system with Freon. During the visit, he discovered that the dryer in the line was contaminated because of the broken joint. Because UBSO will not be operated after 31 December 1969, the dryer was not replaced.

3.10.1.2 Lightning Damage to CRB Power Circuits

During a lightning storm on 5 July, we experienced a large surge on the power line, and the 100-ampere main console circuit breaker was damaged. We received permission from the power company to remove the meter so that we could bypass the faulty circuit breaker. A replacement breaker was installed in the circuit on 4 August.

3.10.2 Equipment Maintenance and Repair

3.10.2.1 Standby Generator

As a result of a severe snow storm on 26 February, several power outages occurred on 26 and 27 February. The standby battery power system operated satisfactorily during the failures, but the standby generator would not operate. The generator, which was obtained as surplus equipment from LASA, is beyond economical repair, and was retired from service.

3.10.2.2 Removal of Surface Array Equipment

In anticipation of the roll-up of UBSO, a local back-hoe contractor was engaged to dig up the old surface array vaults on 12 September. At the same time, the JM seismometers were removed and the vault sites back-filled and leveled.

3.10.2.3 Discontinuance of the Vertical Array

On 8 April, operation of the vertical array seismographs was discontinued in preparation for removal of the array instrumentation from the deep hole. Removal of the Model 11167 seismometers was begun on 29 April. By 2 May, all seismometers of the vertical array were removed from the hole and crated for shipment.

3.10.2.4 Surplus Equipment

During 1969, the following items of equipment were declared surplus and transferred to the indicated agencies:

a. 55 kW power generator donated to Uintah County Civil Defense;

b. 500 W power generator donated to Uintah County School District;

c. Teletypewriter donated to Uintah County School District;

d. Various items of deep-hole equipment, including seismometers, were transferred to McClellan AFB.

3.11 COMMERCIAL POWER CIRCUITS

From the beginning of observatory operation, the commercial power circuits have periodically been unstable and on a few occasions have failed completely. During August 1968, a separate 10 kVA pole transformer was installed to power only the instrumentation circuits. This modification reduced, but did not eliminate line voltage fluctuations.

UBSO experienced a 2-hour and 45-minute commercial power failure on 16 August and a 30-minute failure on 19 August. All emergency systems operated properly during these outages. The commercial power failed again on 7 November for 3 hours and 16 minutes. Because we expected this outage to be of long duration, we borrowed and temporarily installed a small gasoline engine power plant to furnish power to the observatory.

3.12 TIMING SYSTEMS

3.12.1 Primary Station Timing

Primary timing for all observatory instrumentation, except for the long-period digital system, was supplied by the Timing System, Geotech Model 11880. This system performed satisfactorily throughout this reporting period.

3.12.2 Secondary Station Timing

The back-up timing system used an M. Lowe, Inc., synchronome clock as a time standard and supplied 30-second time marks to all recorders whenever the primary timing system failed.

3.12.3 19000 Timing System

A Timing System, Geotech Model 19000, was used exclusively to provide timing pulses and time code for the long-period digital system.

On 14 May, the 19000 timing system began to intermittently output incorrect times, causing word length errors on the digital tape. The problem was traced to a defective voltage regulator which permitted dc power bus noise to enter the timing system and to trigger spurious operations. Because of the magnitude of the noise spikes in the observatory dc power system a separate floating battery using an 18-cell bank of Nicad batteries was installed to power the 19000 timing system.

4. EVALUATION OF SEISMOMETRIC DATA

4.1 STATION PROCEDURES

4.1.1 Analysis Work

In response to the requirements set forth in the Statement of Work to be Done for Project VT/9703, analysis efforts were reduced to a level which provided only the data necessary for the routine daily report to the ESSA-C&GS and the data for tabulating local and small near-regional events. The exchange of daily messages with TFSO was discontinued, but the mailing of daily message copies to BMSO was continued.

4.1.2 Develocorder Film

Starting on 11 February, the 16-mm film seismograms from Develocorders Nos. 2 and 3 were sent to the Geotech laboratory in Garland. These contained data from the long-period digital gain-ranging array and were used to monitor array operation and support evaluation of magnetic-tape seismograms.

4.1.3 Digital Magnetic-Tape Records

The procedure of writing an end-of-file after each interruption in recording on the Kennedy incremental tape recorder was begun on 18 February. On the same day, the use of a double end-of-file to designate completion of a standard 24-hour run was started.

4.1.4 LP Array Equipment Balance

In order to insure the proper operation of the digital-to-analog and analog-to-digital converters in the digital field stations, starting in April, these units were checked and, if necessary, were rebalanced prior to each linearity and frequency response test.

4.1.5 Digital Equipment Performance

On 9 April, a new data channel, ZLP1X, was established to permit performance of the LP array digital equipment to be monitored. ZLP1X used the same seismometer and seismic amplifier as ZLPD1, and was filtered by a standard LP signal control center filter, but bypassed the digital equipment like that used in ZLPD1. The output of the ZLP1X channel was recorded beside the ZLPD1 trace on Develocorder No. 2 and provided a continuous comparison between data which represented the input and the output of the digital equipment in ZLPD1.

4.1.6 Long-Period Calibration Circuits

On 21 April, the long-period calibration circuits were modified to permit LPD1 and LP1 to be calibrated simultaneously with all other long-period seismographs.

4.1.7 Vertical Array

The vertical array was first installed on 5 September 1966 and was operated until July 1967, when equipment malfunctions caused suspension of operations.

The array was reinstalled in February 1968, and was operated intermittently until 8 April 1969, when all associated equipment was shut down. Removal of the seismometers from the deep well began 29 April and was completed in May.

4.1.8 Develocorder Pumps

Because the secondary short-period Develocorder format was not recorded during 1969, two Develocorders were used on alternate days to record primary short-period data. When it was found that 24 hours of inactivity caused difficulty in restarting flow through chemical lines, Develocorder circuits were modified to permit chemical pump operation with the main Develocorder power switch in its off position.

4.2 FREQUENCY RESPONSE STABILITY

4.2.1 Short-Period Seismographs

Each month during the report period, measurements were made at nine frequencies to determine the response of each seismograph in the short-period three-component seismograph system and in the short-period shallow-buried array. When necessary, seismograph operating parameters were adjusted to bring each frequency response within normal operating tolerances. Figure 5 shows the average maximum deviations of all short-period three-component seismographs from the normal operating tolerances and figure 6 shows the average maximum deviations of all short-period buried array seismographs from the normal operating tolerances. Test frequencies and amplitude tolerances are shown in table 2.

4.2.2 Long-Period Seismographs

Monthly measurements were made at 10 frequencies to determine the response of each seismograph in the long-period digital gain-ranging seismograph array and in the long-period three-component (PTA) seismograph system. When necessary, seismograph operating parameters were adjusted to bring each frequency response within normal operating tolerances. Figure 7 shows the average maximum deviations of all long-period digital gain-ranging array seismographs, and figure 8 shows the average maximum deviations of all long-period three-component (PTA) seismographs. Test frequencies and amplitude tolerances are shown in table 2.

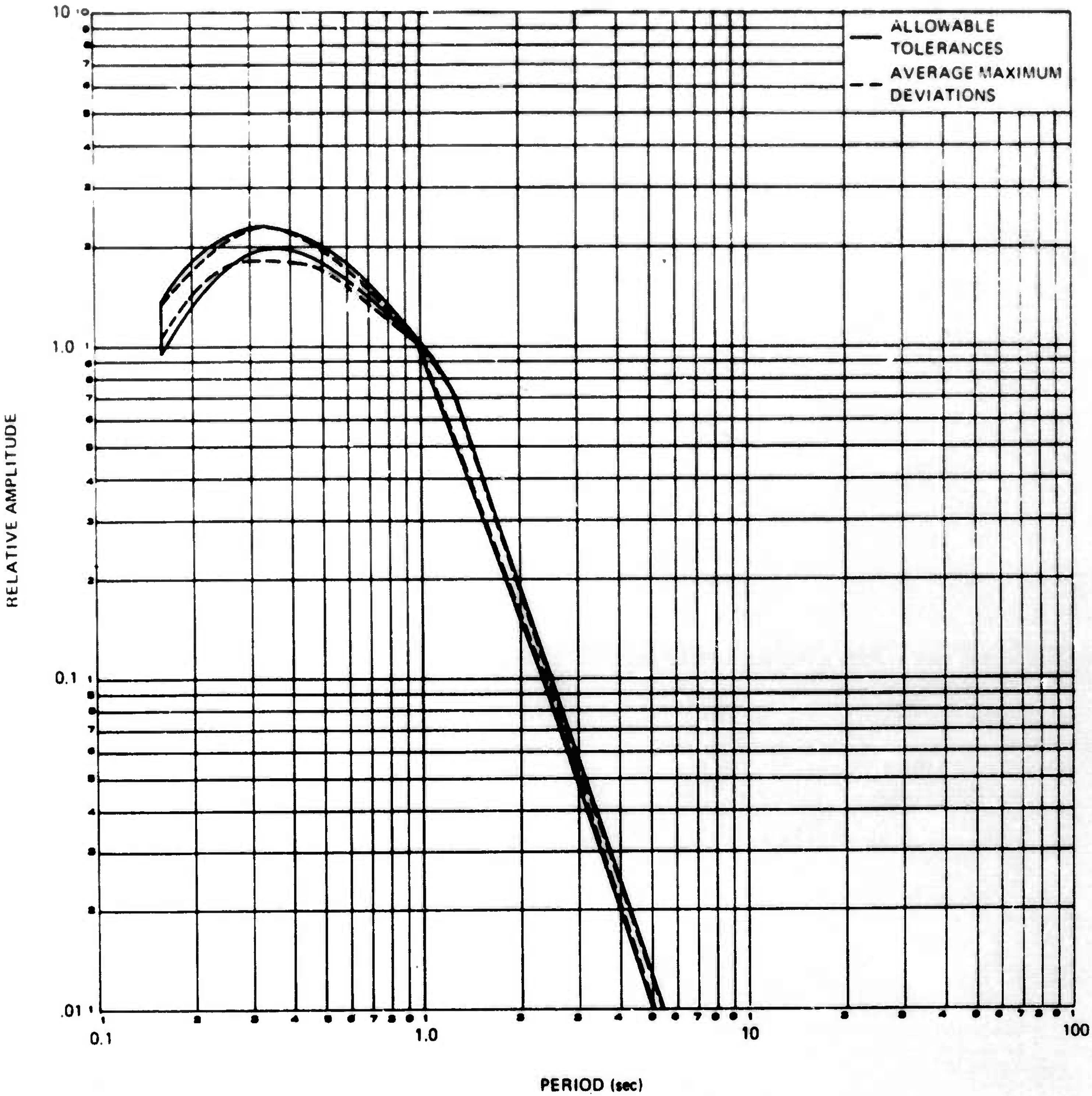

Figure 5. Short-period - three component seismograph frequency response illustrating specified tolerances and average maximum deviations measured during January 1969 through December 1969

G 5726

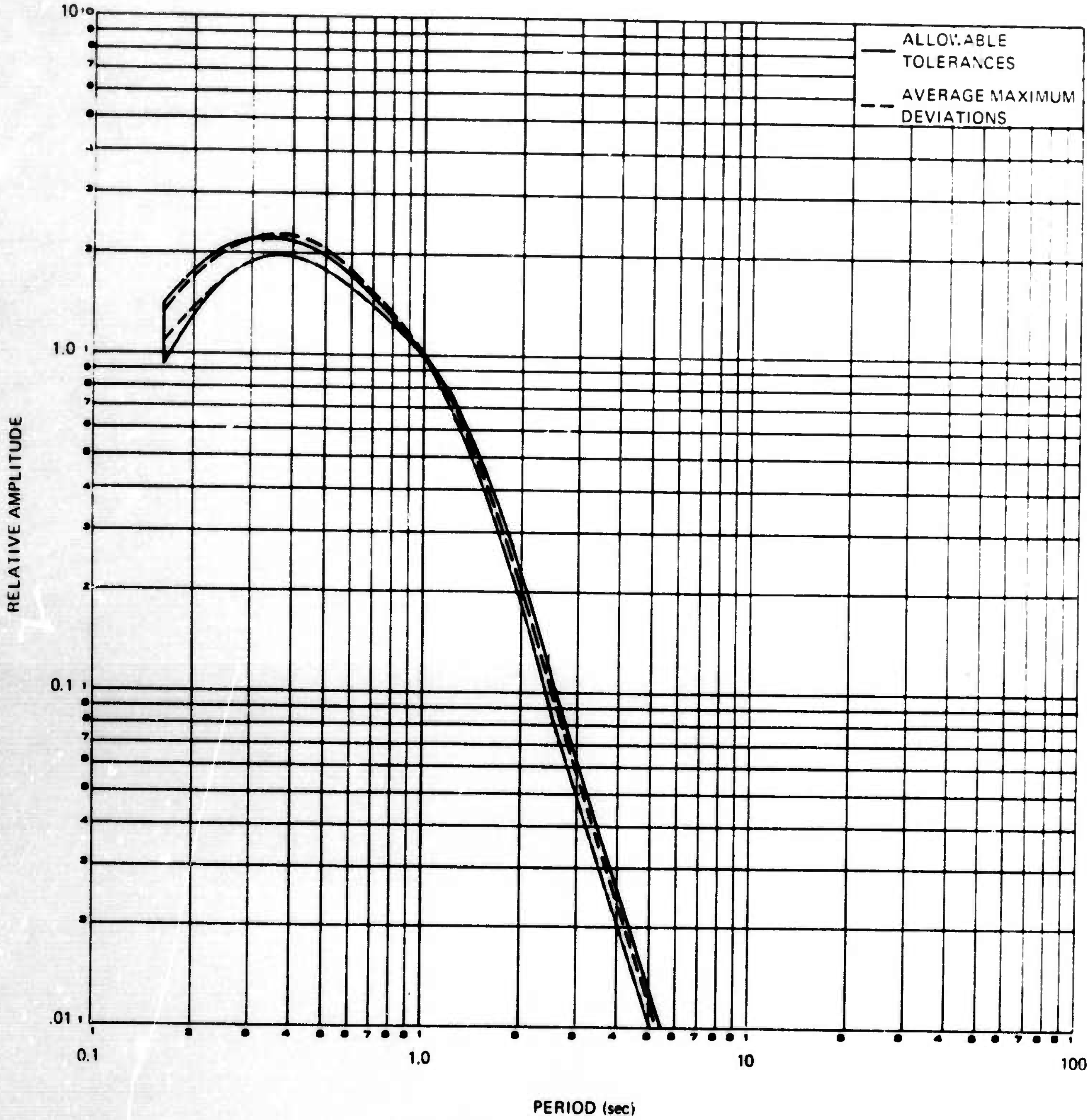

Figure 6. Short-period buried array seismograph frequency response illustrating specified tolerances and average maximum deviations measured during the period January 1969 through December 1969

G 5727

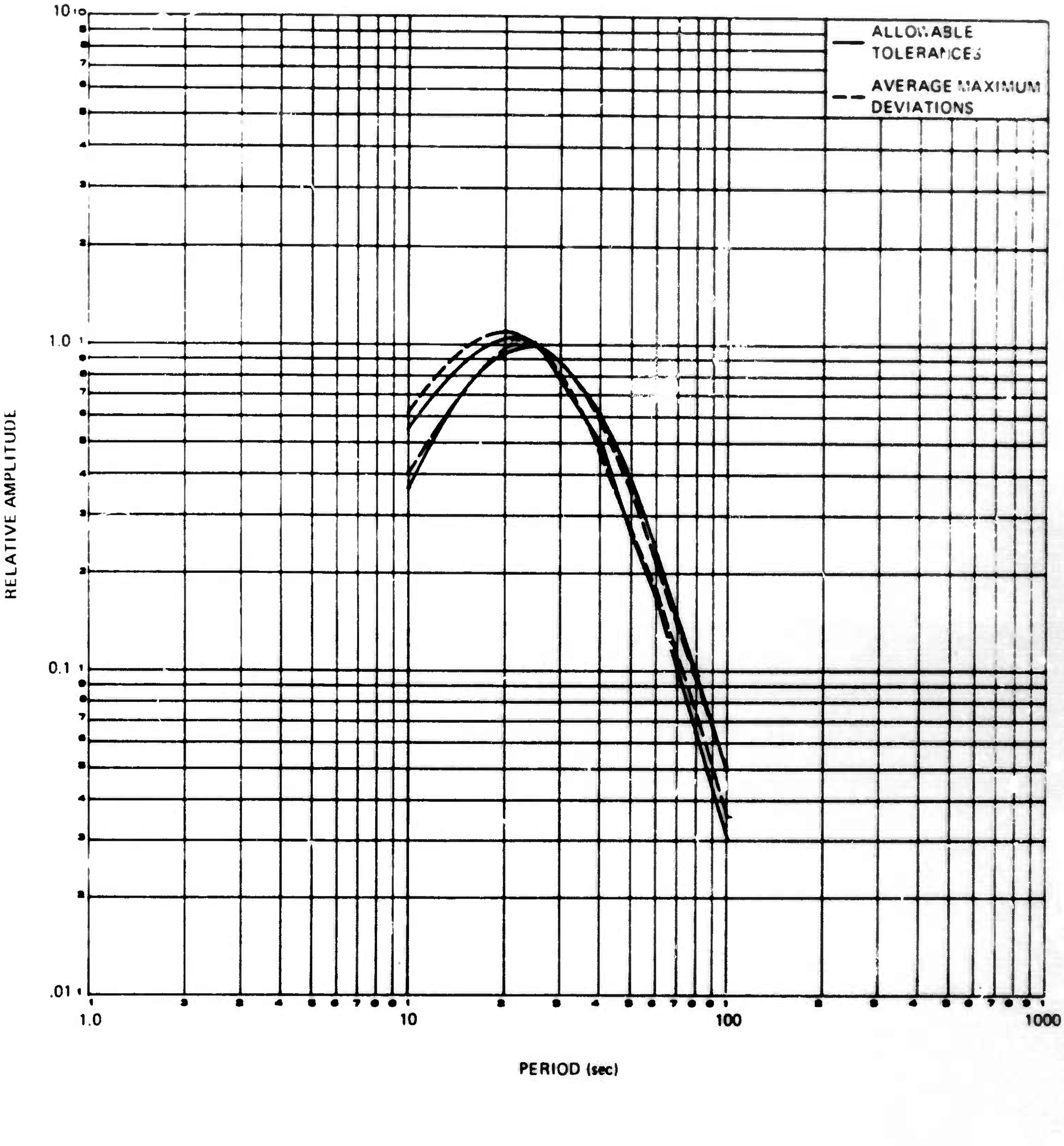

Figure 7. UBSO long-period digital gain-ranging seismograph frequency response illustrating specified tolerances and average maximum deviations measured during the period January 1969 through December 1969

G 5728

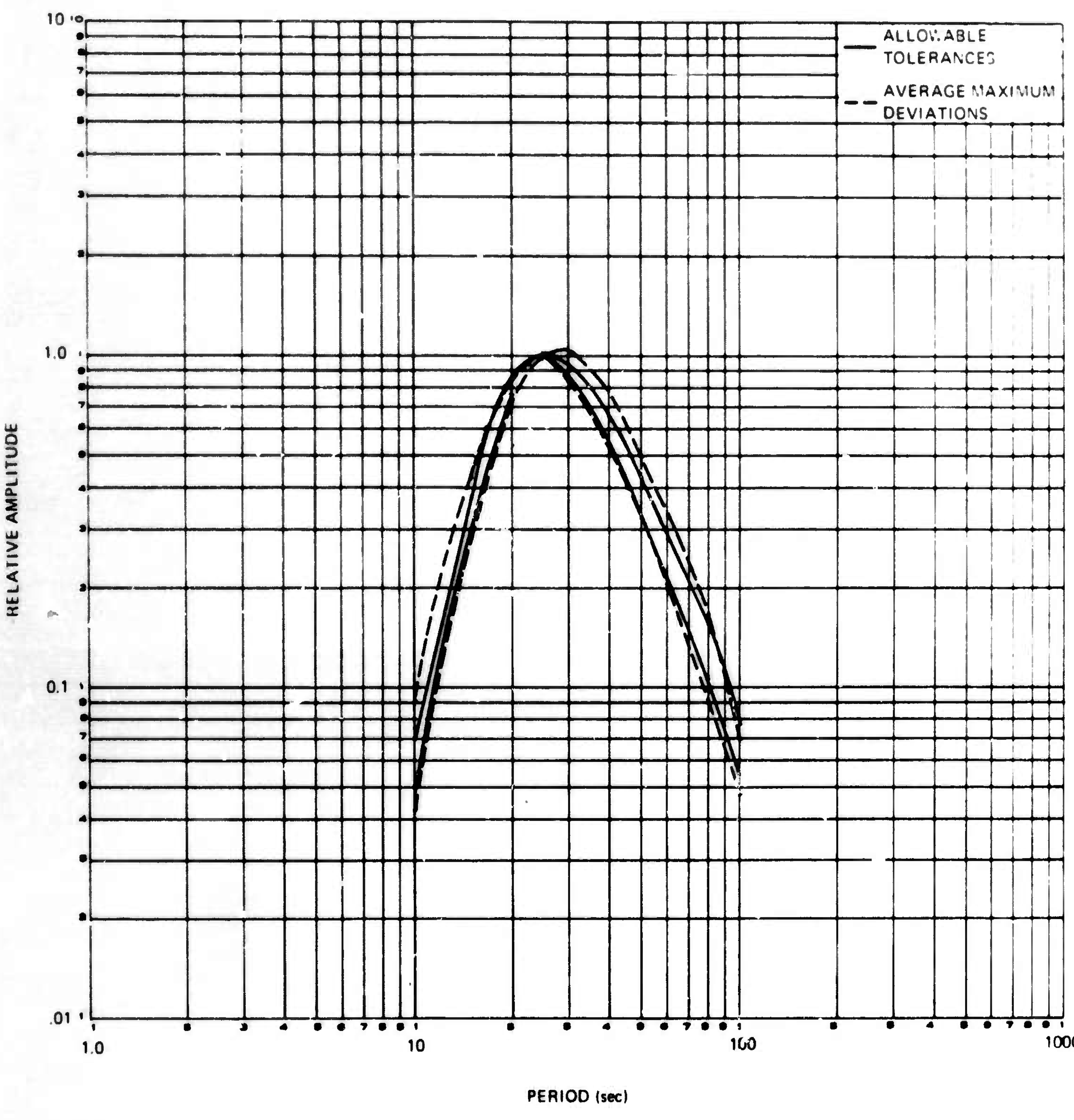

Figure 8. UBSO long-period (PTA) seismograph frequency response illustrating specified tolerances and average maximum deviations measured during the period January 1969 through December 1969

G 5729

5. ROUTINE ANALYSIS

5.1 DATA ANALYSIS

Seismometric data were recorded at UBSO continuously throughout this reporting period. The recorded data were routinely analyzed, the analysis checked and a daily tabulation of arrival times of P phases and selected later phases of earthquake signals transmitted to the Environmental Science Services Administration's Coast and Geodetic Survey (ESSA-C&GS).

Film seismograms were analyzed during each 24-hour period. Analysis was conducted on an "on-line" basis and the analysis data were recorded on worksheets compatible to both observatory use and direct transcription of data to IBM cards. Data recorded during analysis consist of:

a. Phase arrival time;

b. Period and peak amplitude of each phase arrival;

c. Preliminary phase identification when possible;

d. Classification of events by general type (for example, local, near regional);

e. Estimated station-to-epicenter distance and/or azimuth (when possible);

f. Seismograph system and component.

The seismograms were reviewed by a second analyst who checked the arrival time, period, and amplitude data recorded on the worksheets, and reviewed portions of the seismogram classified as "possible signal" by the preliminary analyst. Data from the analysis sheets were used for compilation of information for ESSA-C&GS.

5.2 DAILY REPORTING TO ESSA-C&GS

Throughout the reporting period, the arrival time, signal period, signal amplitude, and estimates of epicentral locations (when estimates were possible) of events recorded at UBSO were reported daily to the ESSA-C&GS in Washington, D.C. Prior to July 1967, the reports were typed at the observatory and wired via the Vernal Western Union office. During July 1967, a Teleprinter was obtained at UBSO, and until August 1968, the message was punched at the observatory and then sent via Western Union. TWX facilities were installed on 1 August 1968. Since that time daily messages, sent by TWX, were relayed to Washington, D. C., by the General Services Administration in Denver, Colorado, on weekdays and were sent directly to Washington, D. C., on weekends and holidays. Data are used by the C&GS in their hypocenter location program.

5.3 EARTHQUAKE BULLETIN

Publication of the VELA-Uniform Earthquake Bulletin, which has been accomplished in the past under observatory contracts, was discontinued after publication of

the December 1968 issue. Completion of the publication of the 1968 issues was accomplished as part of Project VT/9703.

5.4 SUMMARY OF EVENTS RECORDED AND REPORTED

The number of events, by type, reported by UBSO during each month in this reporting period is shown in table 6.

5.5 ROUTINE NOISE MEASUREMENTS

Because of the reduction in the level of effort available for analysis of 16-millimeter film seismograms, we discontinued the practice of routinely collecting background noise data from the daily seismograms during April. Publication of routine noise data was discontinued after the December 1968 noise curves were distributed.

Table 6. Events reported to ESSA-C&GS by UBSO during the period of January through December 1969

Month	Local	Near regional	Regional	Teleseismic	Total
January	9	302	55	915	1281
February	12	294	108	755	1169
March	28	253	249	679	1209
April	25	309	38	593	965
May	10	333	33	678	1054
June	10	451	36	653	1150
July	14	258	19	593	884
August	5	334	48	1581	1968
September	9	406	48	794	1257
October	12	312	32	754	1110
November	1	320	21	758	1100
December	8	285	10	653	956

6. USE OF UBSO FACILITIES BY OTHER GROUPS

6.1 GENERAL

During this contract period there was no work undertaken at UBSO by other organizations.

6.2 PROVIDE DATA TO OTHER ORGANIZATIONS

With the approval of the Project Officer, data were furnished to other interested organizations. Messages containing data about teleseismic, regional, and large near regional events were sent daily by TWX to the ESSA-C&GS. Copies of these messages were mailed to Dr. Kenneth Cook of the University of Utah, to the Blue Mountain Seismological Observatory, Baker, Oregon, and to the Colorado School of Mines. When activity warranted it, data about local and small near-regional events were compiled and were mailed to Dr. Scott Smithson at the University of Wyoming, the United States Geological Survey at Menlo Park, California, the University of Utah, the Colorado School of Mines, and the ESSA-C&GS.

6.3 VISITORS

On 8 and 9 April, Geotech Program Manager, B. B. Leichliter, accompanied Captain F. D. Munzlinger, the outgoing AFTAC Project Officer, and Lieutenant John H. Fergus, incoming Project Officer, on a visit to the observatory. The purpose of the visit was to review Project VT/9703 programs and to orient Lieutenant Fergus. Captain Munzlinger and Lieutenant Fergus visited our Garland laboratory from 28 through 30 April.

Mr. M. G. Gudzin, Project VT/9703 Program Engineer, arrived at UBSO on 27 April to review the status of the operation and to assist in the resolution of operational problems.

Mr. Dean Carder, ESSA-EML, visited the observatory on 8 July.

Miss Linnea Poulsen and Mr. Jesse E. King, Central Intelligence Agency, visited UBSO on 15 July as part of a study of United States scientific capabilities. They were given a tour of the Central Recording Building facilities and of selected field sites.

Messrs. Alvin Kay, Vernal City Mayor, Buell Bennett, Vernal City Manager, and Lyman Merkley, Vernal City Engineer, visited UBSO on 8 August to inspect the CRB and to determine what procedure to follow to obtain the building if it became available to them at the end of the contract.

Lieutenant John H. Fergus, AFTAC Project Officer, and Mr. M. G. Gudzin, Geotech, visited the Observatory on 8 September.

Mr. William O'Connell, DCASR-SLC, visited UBSO on 11 September to check and inspect selected items of U. S. Government property assigned to Contract 0759.

Dr. Frank Pilotte, AFTAC, Mr. Donald H. Clements, OSD/ARPA, and Mr. William J. Best, AFOSR, visited UBSO on 6 October to review problems concerned with closing the observatory, disposing of observatory equipment, and restoring the land to its original condition.

7. SPECIAL INVESTIGATIONS

7.1 EVALUATION OF THE LONG-PERIOD ARRAY DETECTION CAPABILITY

Data from the UBSO long-period array were processed by simple summation and by beam-steering techniques to determine the signal-to-noise ratio enhancement this array provides over a single detector. Results of this study have been published separately as Technical Report No. 69-53, Evaluation of the UBSO Long-Period Array Detection Capability.

7.2 EVALUATION OF THE LONG-PERIOD ARRAY SYSTEM RELIABILITY

7.2.1 General

The reliability of the long-period array system was evaluated in terms of operational failures using data taken from the observatory maintenance records. An operational failure was considered to occur whenever recorded data from one or more channels was totally unusable for reasons of severe distortion, instrumentation noise, or complete signal loss. In addition, calibration and timing equipment malfunctions were considered failures. Short periods of lost or noisy data caused by intermittent, self-restoring power drop-outs, or by line voltage fluctuations, or by telephone circuit noise, were not considered failures, but rather, were considered periods of reduced performance and were outside the scope of this evaluation. A total of 143 operational failures occurred in the long-period array system during the calendar year of 1969. Figures 9 through 13 present percentage distributions of these failures with respect to instrument groups, site, date, and cause of failure.

The failure data presented in this report are, in general, not representative of the operating time lost, but are based on a simple count of the number of failures. The time lost per failure varied greatly, depending on the priority of other observatory work, the diagnosis time, the availability of replacement parts, and the actual maintenance time.

7.2.2 Seismometers

Thirty percent of the seismometer failures were caused by incorrect installations due to wiring errors or use of incorrect electrical components and should probably be considered part of the normal debugging required in a large data acquisition system. Other outages were caused by loss of a case seal, spiking (mechanical instability) of a vertical instrument, and failure (by rusting) of remote period adjust and mass position adjust motors. There were no seismometer failures during the last 6 months of 1969, indicating that the seismometer circuits were satisfactorily debugged and the weaker components had been replaced or repaired. Previous experience has shown that rusting of remote accessory motors is not a problem except in installations where humidity is so high that moisture condenses on instrumentation. This condition should not exist if the vaults are ventilated during dry weather and entered infrequently.

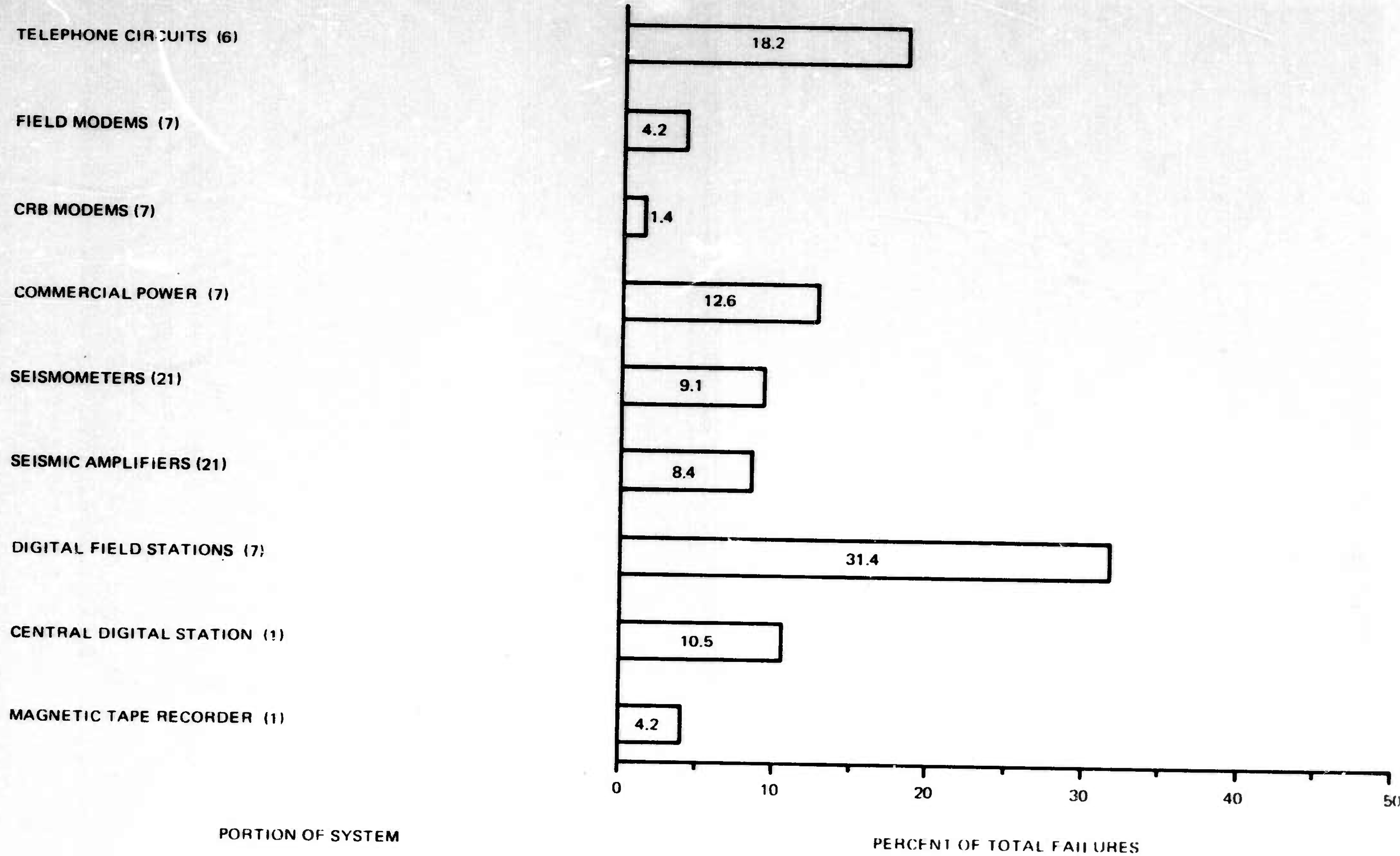

Figure 9. Percentage distribution of operational failures in the major portions of the UBSO long-period array system from 1 January to 31 December 1969

G 5730

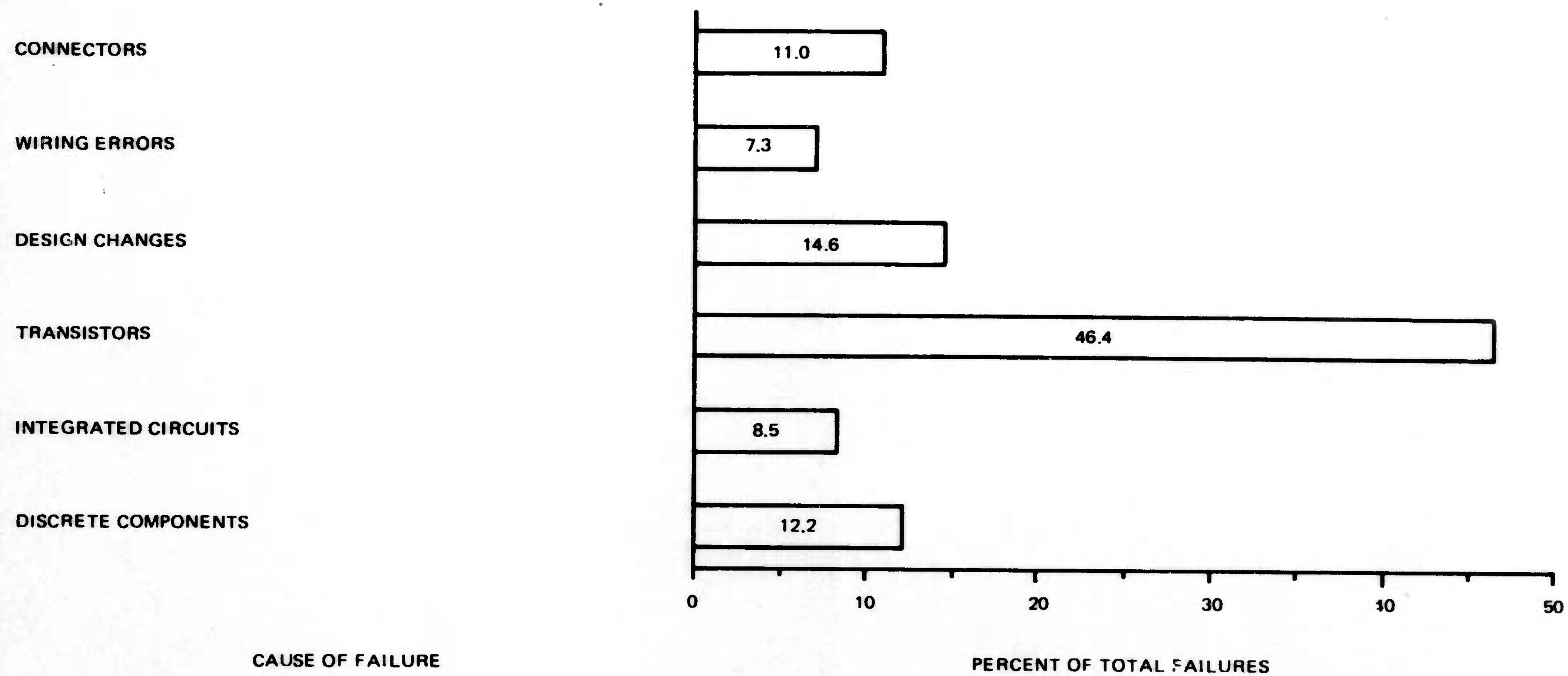

Figure 10. Percentage distribution by cause of operational failures in the digital acquisition system of the UBSO long-period array system. Data are for failures in the Digital Field Stations, the Central Digital Station and the incremental tape recorder

G 5731

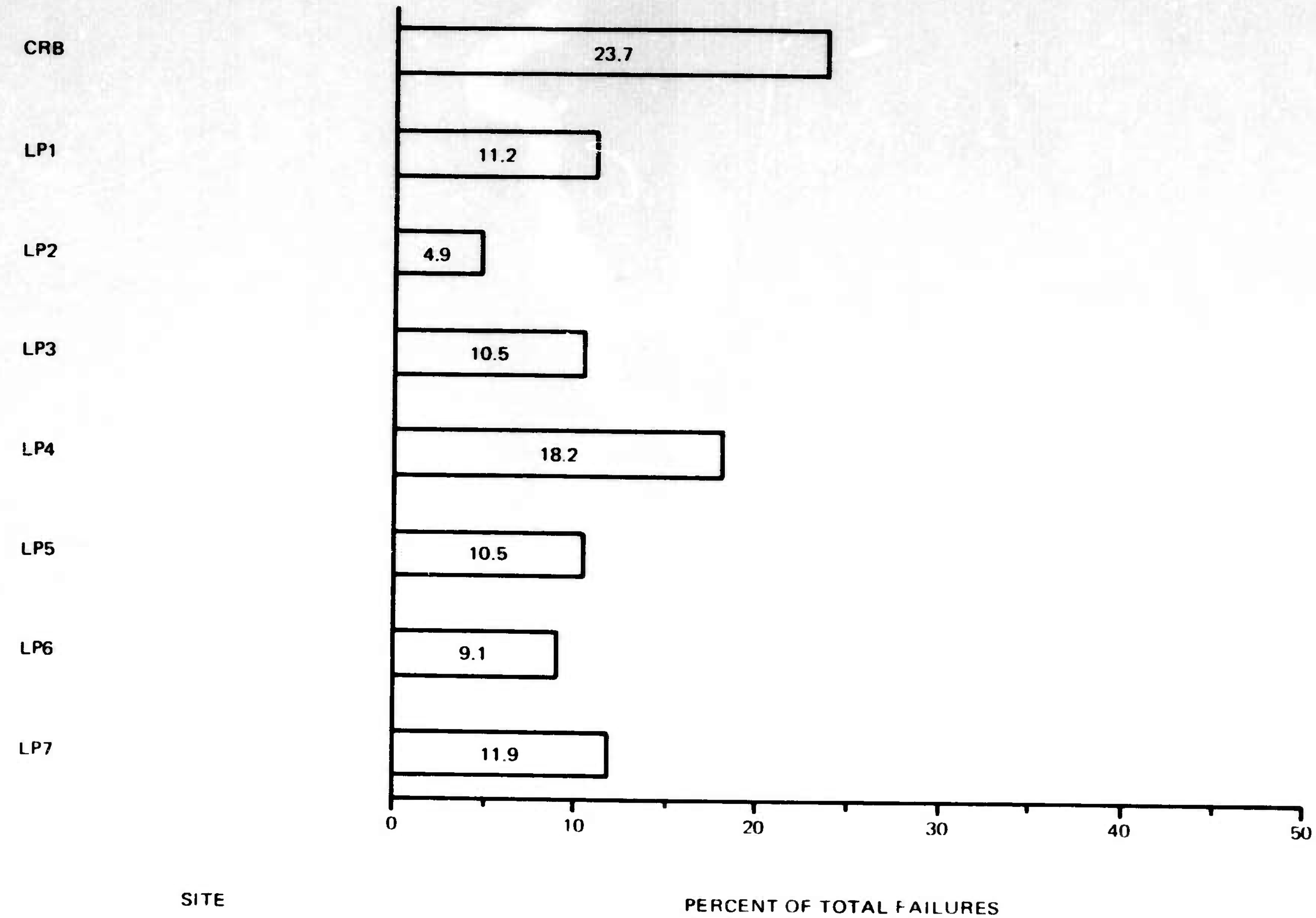

Figure 11. Percentage distribution by site of operational failures in the UBSO long-period array system from 1 January to 31 December 1969

G 5732

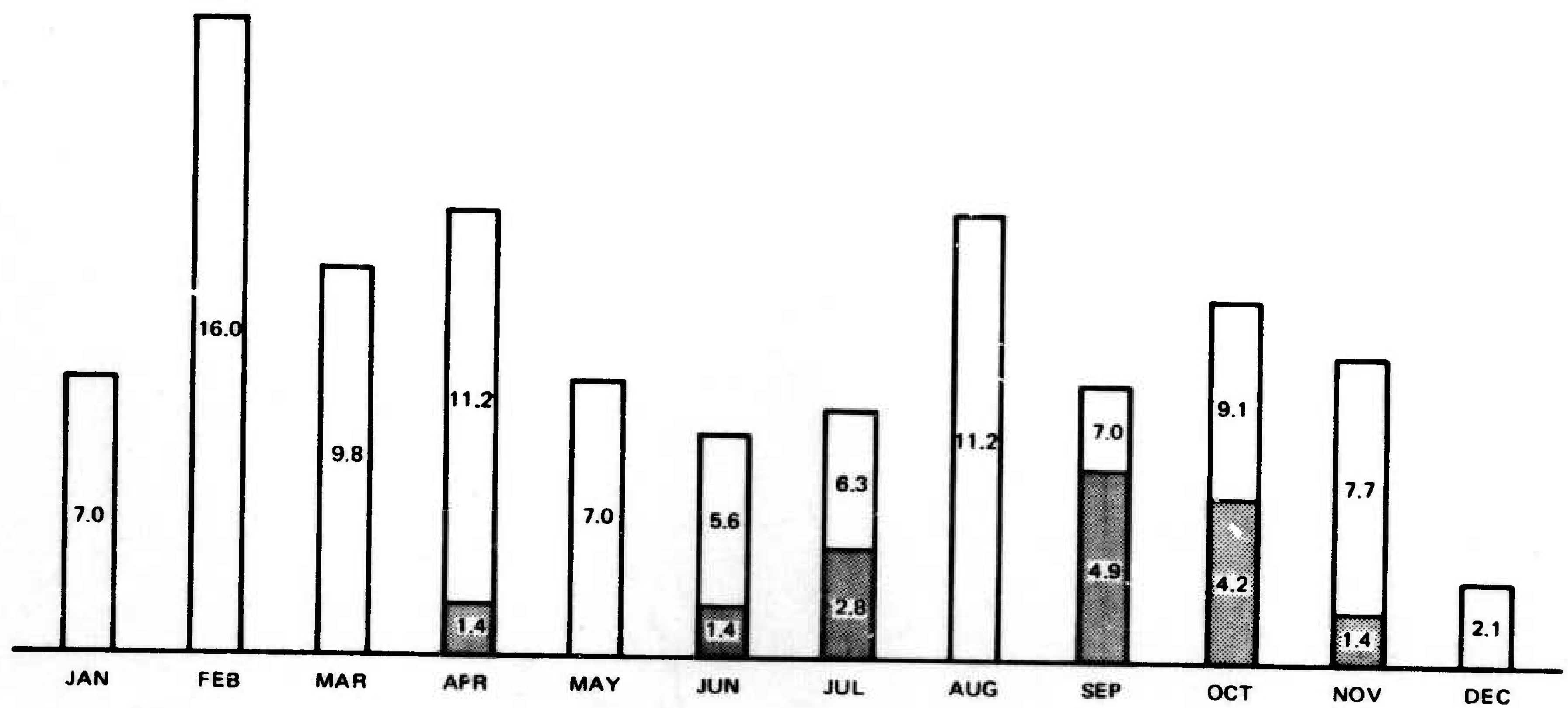

Figure 12. Percentage distribution by month of operational failures in the UBSO long-period array system from 1 January to 31 December 1969. Shaded areas represent portion of failures due to lightning

G 5733

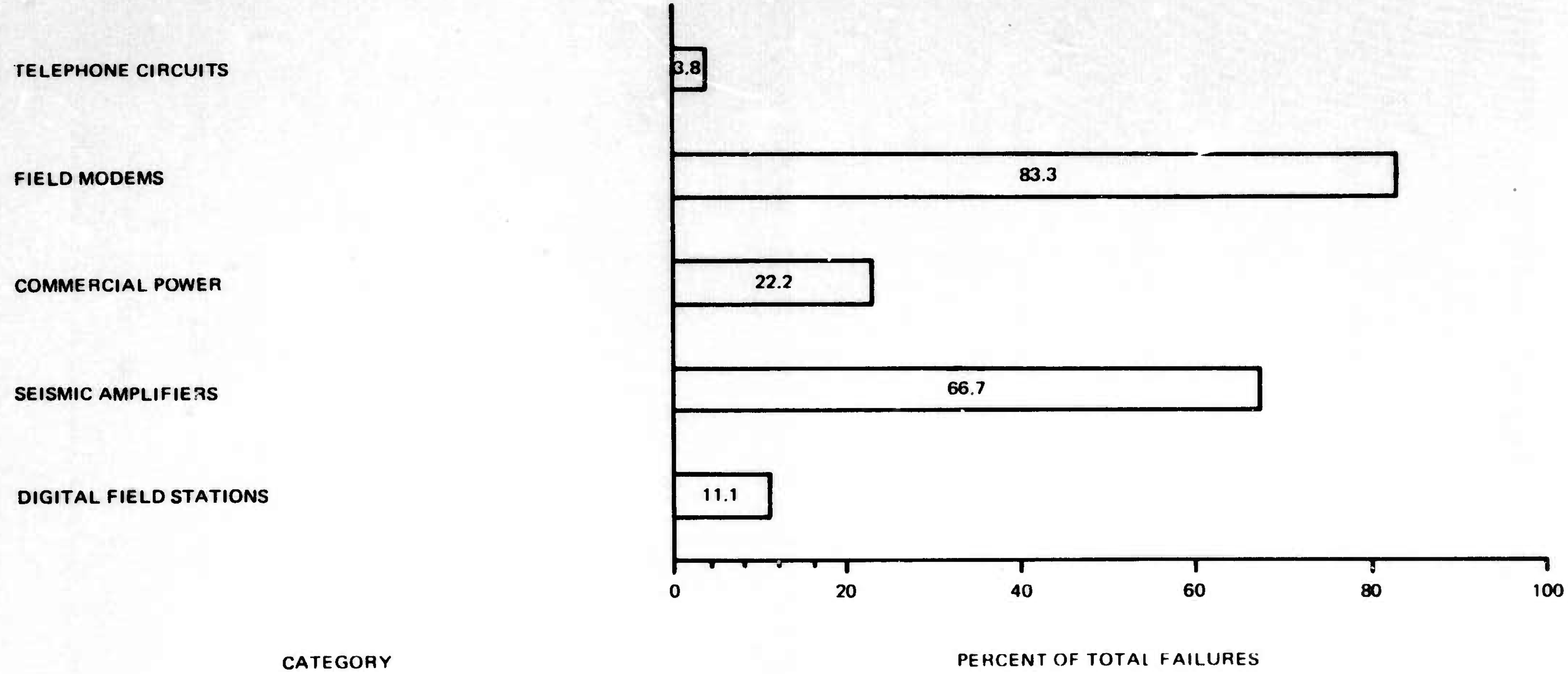

Figure 13. Lightning-induced operational failures in the UBSO long-period array system from 1 January to 31 December 1969 presented as a percentage of the total failures in each category

G 5734

7.2.3 Seismic Amplifiers

Lightning-induced voltage surges destroyed diodes and transistors in several seismic amplifiers and caused 66.7 percent of their failures during 1969. This was unexpected, as historically, the incidence of lightning activity at UBSO has been very small, and lightning damage previous to 1969 was nonexistent. If operation of this system were to be continued, it would have been recommended that circuits be developed and installed to protect the seismic amplifiers. However, because UBSO operation was scheduled to terminate on 31 December 1969, and the likelihood of additional lightning activity in the area was small, amplifiers were repaired as they were damaged and no modification program was undertaken.

7.2.4 Digital Field and Central Digital Stations

Although equipped with different logic circuits, the Digital Field Stations and the Central Digital Station use identical or similar components and construction, and hence are evaluated together. Figure 9 shows that 41.9 percent of the total system failures occurred in these units and figure 10 shows that 46.4 percent of these were caused by transistors. These high percentages reflect the complexity of these equipments, which use approximately 20,000 separate transistors and 3400 integrated circuits. During the year, 38, or approximately 0.2 percent of the transistors failed, and 7, or approximately 0.2 percent of the integrated circuits failed. It is interesting to note that discrete components failed at a higher rate than did integrated circuits.

UBSO personnel indicate that the connector failure figure of 11.0 percent is incorrect, and that they did not begin documenting open circuits or poor connections at printed-circuit card connectors until late in 1969 because they could be repaired by simply bending the connector prongs. They found that these fork-type connectors usually maintained good contact after being adjusted once or after each replacement of a printed-circuit card. It was estimated that during the first 6 months of 1969, 60 percent of all operational failures were caused by faulty contacts on printed-circuit card assemblies, and that this figure fell to 10 percent during the last 6 months.

Wiring errors and required design changes, normally considered debugging activities during establishment of a digital acquisition system, were included in figure 10 to indicate the degree of effort required. Nearly 22 percent of the operational failures were credited to this activity. All may be considered one-time jobs.

7.2.5 Field Modems

All field modems, which modulated the Digital Field Station data outputs for transmission over telephone circuits, were leased from and maintained by the telephone company. Their performance was good, but they suffered heavy lightning damage until they were equipped with commercially available protective circuits. During the year, there were six modem failures, five due to lightning, but their contribution to overall system outage time was disproportionately high, for the telephone company kept only one spare unit, causing long-term loss of data from one site when two modems failed simultaneously.

7.2.6 Telephone Circuits

Following Digital Field Stations, telephone circuits experienced the second largest rate, 18.2 percent, of operational failures. This was expected, as the lines connect a central recording building with field sites scattered over 1000 square miles of sparsely populated land. Most telephone circuit failures were caused by the usual broken line, broken insulator due to gunshot, etc., but others were rather unusual and, being difficult to diagnose, caused transmission interruptions for long periods of time. For example, an abnormally high rate of transmission parity errors were received with data from LP3. Their occurrence was intermittent and could not be correlated with lightning activity, radio transmissions, commercial line voltage fluctuations, or any other observable phenomena. Finally, through cooperative effort of observatory and telephone company personnel the trouble was traced to a fault from line to ground on the line to LP3. Because the ringing circuit in Jensen, Utah, is tied to the same ground, transmissions from LP3 were lost whenever a telephone rang in Jensen.

7.2.7 Central Recording Building Modem

Late in 1969, two central recording building modems failed. Neither failure was caused by lightning and the telephone company promptly replaced the units holding outage time to a minimum.

7.2.8 Magnetic-Tape Recorder

Figure 9 indicates that the magnetic-tape recorder, an Incremental Magnetic Recorder, Kennedy Model DS370-R5, was responsible for 4.2 percent of the long-period array system failures. More correctly, 4.2 percent of the system repairs were performed upon the Kennedy recorder. Early in the year, operational failures of the recorder were frequently difficult to detect uniquely -- that is, to isolate from other system malfunctions. Later, as the system debugging progressed, recorder malfunctions became identifiable, and work was directed more strongly towards improving recorder performance. Playouts of tape from the Kennedy recorder contained three easily detectable types of errors that could be caused by the recorder: incorrect word lengths, tape parity errors, and timing errors. Early in the year, many incorrect word lengths were found to be produced by spurious noise pulses entering the recording circuits through the power supply. After this source was eliminated, incorrect record lengths, and also tape parity errors and timing errors, continued to occur intermittently, but at an unacceptable rate. It was found that defective magnetic tapes caused some of these errors, but that most were caused by the recorder. It was also noted that some tape damage was apparently caused by the recorder. On-site work by a manufacturer's representative improved recorder performance slightly, but satisfactory performance was not realized until after the machine had been returned to the factory for overhaul.

On the basis of experience with the Kennedy recorder after conferences with its manufacturer, it was concluded that, to keep this machine satisfactorily operational, it will probably require overhaul once per year, that its pinch-roller and tape-guide mechanisms could wear and become misaligned during that time period. Such an overhaul requirement would result in the loss of approximately 1 week of data each year or would require the provision of a spare recorder. In the interest of avoiding these alternatives, the use of other incremental

magnetic-tape recorders was considered. The Peripheral Equipment Corporation (PEC) Model 2523-7 recorder, which uses a single capstan drive and no pinch rollers, and which should require infrequent adjustment and overhaul, appeared to be the best machine for this application. One such recorder was obtained from PEC on a trial basis and was installed at UBSO for testing. Long-period digital data were recorded simultaneously on both the PEC and the Kennedy units from 30 April to 16 June. The PEC recorder performed satisfactorily for 16 of the 46 days, but was inoperative the other 30 days due to failures of four different electronic components. During the same time period, all mechanical components of the PEC tape transport performed satisfactorily. From these limited tests and from close examinations of both recorders, it was concluded that for long-term continuous duty at the observatory, the PEC recorder should be used, and that following initial debugging of its electronic circuits, the unit would prove more reliable than the Kennedy recorder.

7.2.9 Commercial Power

As with telephone circuits, the commercial power circuits connect to the central recording building and to field sites scattered over 1000 square miles of sparsely populated land and experience higher failure rates and slower maintenance than would be expected in a more densely populated area. Figure 9 shows that 12.6 percent of the long-period array system operational failures were caused by major commercial power interruptions. During any period of unattended operation, each commercial power outage at the central recording building caused loss of all long-period array data for the duration of the outage as the Central Digital Station equipment operated from line power and had no automatically switched backup. Also, all field sites except LP7 operated on line power with no backup. LP7 operated from a thermoelectric generator and lost power only once -- when the thermoelectric generator failed and required repairs. The foregoing data indicate that, although the long-period seismic digital acquisition system was an experimental system designed, built, and installed on an extremely restrictive budget, its reliability would have been greatly enhanced by the inclusion of backup, automatic switchover power equipment.

8. REPORTS AND TECHNICAL DATA PUBLISHED UNDER PROJECT VT/9703

The following is a list of the reports and documents published under Project VT/9703:

a. Technical Report No. 69-15, Operation of the Uinta Basin Seismological Observatory, Quarterly Report No. 1, 1 January through 31 March 1969.

b. Technical Report No. 69-19, Design, Installation, and Preliminary Evaluation of the UBSO Long-Period Digital Data Acquisition System.

c. Technical Report No. 69-26, Operation of the Uinta Basin Seismological Observatory, Quarterly Report No. 2, Project VT/9703, 1 April through 30 June 1969.

d. Technical Report No. 69-49, Operation of the Uinta Basin Seismological Observatory, Quarterly Report No. 3, Project VT/9703, 1 July through 30 September 1969.

e. "Long-Period Digital System at UBSO: Failure History, and Anticipated Problems in Move to TFSO," letter report dated 8 July 1969.

f. "Feasibility and Desirability of Moving the LP Digital Data Acquisition System from UBSO to TFSO," letter report dated 23 July 1969.

g. Technical Report No. 69-53, Evaluation of the UBSO Long-Period Array Detection Capability.

APPENDIX 1 to TECHNICAL REPORT NO. 70-2

STATEMENT OF WORK TO BE DONE

AFTAC Project Authorization No. VELA T/9703

STATEMENT OF WORK TO BE DONE
(AFTAC Project Authorization No. VELA T/9703/S/ASD) (32)

OCT 1 4 1966

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Tasks:

a. Operation:

(1) Continue operation of the Uinta Basin Seismological Observatory (UBSO), normally recording data continuously.

(2) Evaluate the seismic data to determine optimum operational characteristics and make changes in the operating parameters as may be required to provide the most effective observatory possible. Addition and modification of instruments are within the scope of work. However, such instrument modifications and additions, data evaluation, and major parameter changes are subject to the prior approval of AFTAC.

(3) Conduct routine daily analysis of seismic data at the observatory and transmit daily seismic teletype reports to the Coast and Geodetic Survey, Environmental Science Services Administration, Washington Science Center, Rockville, Maryland, using the established report format and detailed instructions.

(4) Establish quality control procedures and conduct quality control, as necessary, to assure the recording of high-quality data on both magnetic tape and film. Past experience indicates that a quality control review of one magnetic tape per magnetic tape recorder at the observatory during each week is satisfactory unless quality control tolerances have been exceeded and the necessity of additional quality control arises. Quality control of magnetic tape should include, but need not necessarily be limited to, the following items:

(a) Completeness and accuracy of operation logs.

(b) Accuracy of observatory measurements of system noise and equivalent ground motion.

(c) Quality and completeness of voice comments.

(d) Examination of all calibrations to assure that clipping does not occur.

(e) Determination of relative phase shift on all array seismographs.

(f) Measurement of DC unbalance.

(g) Presence and accuracy of tape calibration and alignment.

(h) Check of uncompensated noise on each channel.

(i) Check of uncompensated signal-to-noise of channel 7.

Atch 1

(j) Check of general strength and quality of timing data derived from National Bureau of Standards Station WWV.

(k) Check of time pulse modulated 60 cps on channel 14 for adequate signal level and for presence of time pulses.

(l) Check of synchronization of digital time encoder with WWV.

(5) Provide observatory facilities, accompanying technical assistance by observatory personnel, and seismological data to requesting organizations and individuals after approval by the project officer.

(6) Maintain, repair, protect, and preserve the facilities of UBSO in good physical condition in accordance with sound industrial practice.

b. Special Investigations:

(1) Conduct research investigations as approved or requested by the project officer to obtain fundamental information which will lead to improvements in the detection capability of UBSO. These programs should take advantage of geological, meteorological, and seismological conditions of the observatory. The following special studies should be accomplished:

(a) Evaluate the long-period array.

(b) Evaluate the digital data transmission and acquisition system.

(c) Continue evaluation of deep-well vertical arrays.

(2) Prior to commencing any research investigation, AFTAC approval of the proposed investigation and of a comprehensive program outline of the intended research must be obtained.

APPENDIX 2 to TECHNICAL REPORT NO. 70-2

UBSO DIGITAL LONG-PERIOD TAPE FORMAT

DIGITAL TAPE FORMAT

1. DEFINITIONS

1.1 DATA WORD

A data word is one sample of data from one sensor. There are two types of data words. The first contains a 12-bit sample of seismic data plus a 4-bit gain value and two spare bits. The gain value indicates the amount by which the 12-bit quantity was amplified during digitization. The gain value will, in general, change from sample to sample; therefore, in using the data, one should normalize the samples to one selected gain.

The second type of data word is an 18-bit quantity containing supervisory information from each remote station.

See table 1 for the detector identity coding.

1.2 TIME WORD

The time word is a 48-bit quantity which contains the GCT time in hours, minutes, and seconds of the first scan of the preceding record.

1.3 TRANSMIT DATA WORD

The transmit data word is a 48-bit quantity which contains any data or instruction codes that were transmitted to the remote stations during the previous second.

1.4 SCAN

A scan contains all the data for a one-second sample period, i.e., one sample from each of the 21 seismometers plus the transmit data word and the supervisory data from station. At the end of each scan are four spare tape frames for the purpose of making each scan an integral number of 24-bit or 48-bit computer words.

1.5 DATA RECORD

A data record contains all the data for a 60-second sample period. The first word of each data record is a time word, which is followed by 60 scans. Each data record is preceded and followed by a 3/4-inch tape gap.

1.6 HEADER RECORD

The header record is a 96-bit quantity constituting the first record on a tape. It contains accessory data such as the date and observatory identification.

2. FORMATS

2.1 DATA WORD (two types)

2.1.1 Data Word (seismic data)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
sign	data value											gain cod				spare	

The data value and sign are in one's complement representation. The gain code (GC) is a binary representation of the power minus 1 to which the base 2 has been raised and represents the factor by which the data value was amplified. The value of the least significant bit (LSB) of the 12-bit (11 bits plus sign) data value is determined as follows:

$$LSB = 2^{(11-GC)}$$

Thus, the gain code can be considered to be the LSB scaling value.

2.1.2 Data Word (supervisory data)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
sign	data value					F_1	F_2	F_3	F_4	X	A	spare					

where F_1 = 1 means one of the two motors of the Z instrument is on

F_2 = 1 means one of the two motors of the N instrument is on

F_3 = 1 means one of the two motors of the E instrument is on

F_4 = 1 means a new function has been received from the central station

X — is a parity bit (transmission parity)

A — indicates a transmission parity error

The data value has one's complement representation with the bit values being, from left to right, 2^{10}, 2^{9}, 2^{8}, 2^{7}, and 2^{6}. The data value contains the result of monitoring functions such as dc voltage, fuel, temperature, and mass position.

2.2 TIME WORD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
tens						units						tens					
hours												minutes					

18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
units						tens						units					
minutes						seconds											

36	37	38	39	40	41	42	43	44	45	46	47
spare											

The time is in BCD representation.

2.3 TRANSMIT DATA WORD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
±	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Data												Station ID					

18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	C	M
Spare		Function address				Spare		Sub-address				Spare			Command		

36	37	38	39	40	41	42	43	44	45	46	47
0	0	0	0	0	0	0	0	0	0	0	0
Spare											

Data - A binary value with one's complement representation. It contains a calibration sample that is sent to the station when an instrument is being calibrated.

Station ID - Indicates the station at which a selected function is to be performed or cleared. Its value can be 1 through 7. If all bits are loaded, the function will be performed at all stations.

Function address - Indicates a function. See table 2 for function code.

Sub address - Additional coding for a function such as which instrument, what to be monitored (DCV, fuel, temperature, or mass), direction of motor, etc. (See table 2 for code.)

Command

I - Execute the coded function at the station selected until cleared.

C - Clear (stop) the coded function at the station selected.

M - Master clear - stops all functions (except the digital sampling) at the station selected.

2.4 HEADER RECORD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
thousands						hundreds						tens						unit					

Year (BCD)

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hundreds						tens						units					

Day (BCD)

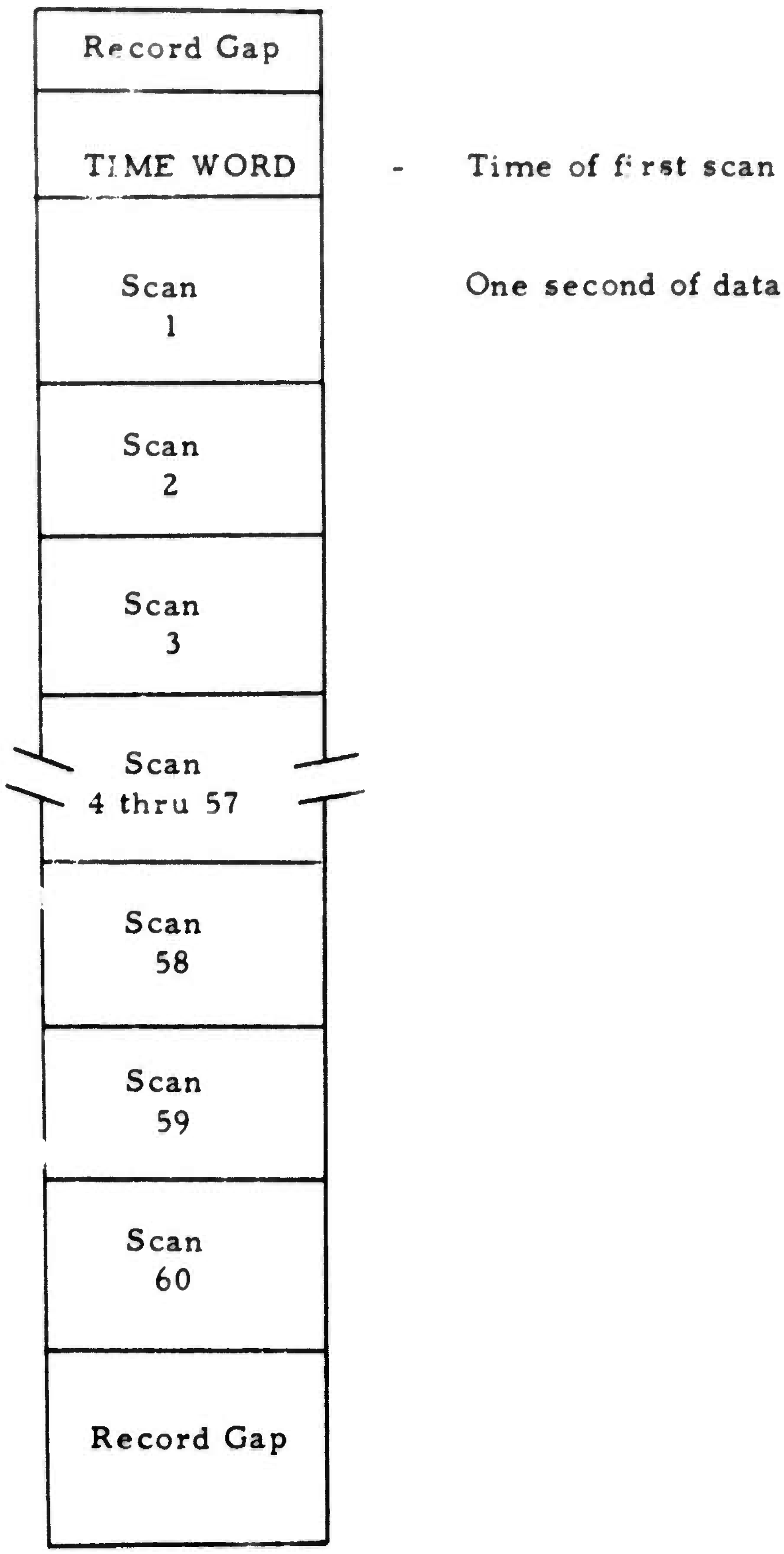
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Data Group Number (BCD)																							

66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Station ID (BCD)																		Spare											

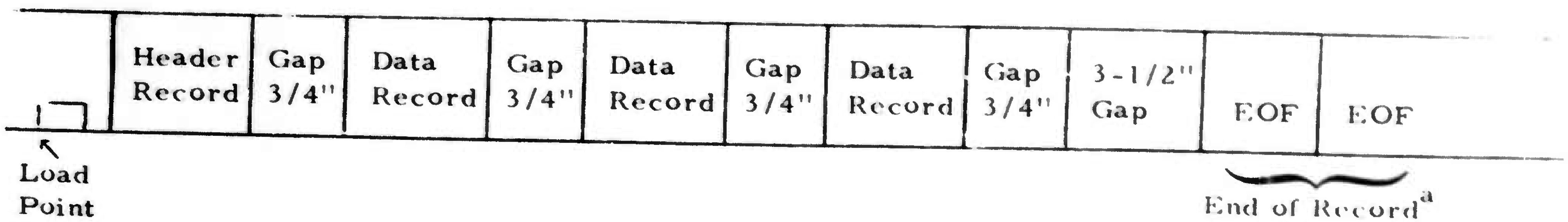
2.5 SCAN

Transmit Data Word	
Data Word $_{1,1}$	
Data Word $_{2,1}$	
Data Word $_{3,1}$	
Data Word $_{4,1}$	Data samples from the Z instrument from the seven stations
Data Word $_{5,1}$	
Data Word $_{6,1}$	
Data Word $_{7,1}$	
Data Word $_{1,2}$	
Data Word $_{2,2}$	
Data Word $_{3,2}$	
Data Word $_{4,2}$	Data samples from the N instruments from the seven stations
Data Word $_{5,2}$	
Data Word $_{6,2}$	
Data Word $_{7,2}$	
Data Word $_{1,3}$	
Data Word $_{2,3}$	
Data Word $_{3,3}$	
Data Word $_{4,3}$	Data samples from the E instruments from the seven stations
Data Word $_{5,3}$	
Data Word $_{6,3}$	
Data Word $_{7,3}$	
Data Word $_{1,4}$	
Data Word $_{2,4}$	
Data Word $_{3,4}$	Supervisory data from the seven stations
Data Word $_{4,4}$	
Data Word $_{5,4}$	
Data Word $_{6,4}$	
Data Word $_{7,4}$	
	Four spare tape frames

2.6 DATA RECORD



2.7 TAPE FORMAT



[a]Two consecutive ends-of-file (EOF) indicate end-of-record; EOF will occur in record when data are restarted after equipment malfunction or other outage (e.g., power failure)

TABLE 1

***Station Identities**

i	
1	Vault 1
2	Vault 2
3	Vault 3
4	Vault 4
5	Vault 5
6	Vault 6
7	Vault 7

Detector Identities

j	
1	Z
2	N
3	E
4	Supervisory

*At the time of writing the station identities are not firmly established.

TABLE 2

Function Address		*Sub-Address	
Function	Bit pattern	Description	Bit pattern
System monitor	0001	DCV	0001
		Fuel	0010
		Temperature	0100
Cal	0010	Z instrument	0001
		N instrument	0010
		E instrument	0100
		All instruments	0111
		Z cal free period	1001
		N cal free period	1010
		E cal free period	1100
		All cal free periods	1111
Monitor mass	0011	Z	0001
		N	0010
		E	0100
Position mass	0101	Z instrument (+)	0001
		Z instrument (-)	1001
		N instrument (+)	0010
		N instrument (-)	1010
		E instrument (+)	0100
		E instrument (-)	1100
Adjust period	0110	Z instrument (+)	0001
		Z instrument (-)	1001
		N instrument (+)	0010
		N instrument (-)	1010
		E instrument (+)	0100
		E instrument (-)	1100
Station control	1110	Enable power	0001
		Not assigned	0010
		Inhibit BGA	0100

If no monitoring function is selected DCV will be monitored.

*The code of the sub-address depends on what function is selected.

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13. ABSTRACT

This report describes the operations of the Uinta Basin Seismological Observatory (UBSO) from 1 January through 31 December 1969. Also discussed are the maintenance and testing of the UBSO digital data acquisition system. ( )

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Long-Period Array						
Seismograph Operating Parameters						
Digital Field Station						
Central Digital Station						